Oil Refinery Specifications

BY

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THIS BOOK,

Is respectfully dedicated to those whose kindness has enabled me to produce it.

TO MY PARENTS,

Who gave me the education upon which it is based.

TO MY WIFE,

Rose B. Nugey,

For her loving sympathy, encouragement and assistance.

PREFACE.

For several years, an urgent need has been felt for a condensed book of specifications on subjects pertaining to equipment used in refining petroleum. With this object in mind, the author has therefore prepared this treatise on "Oil Refinery Specifications" covering modern American practice in the safe design, construction and renovation of petroleum refineries.

Only a brief description of the various processes need be given in this volume because of the vast number of petroleum books which cover the various processes in lengthy detail. The author's lengthy experience both in the design and construction of refineries enables him to safely recommend the various pieces of equipment necessary for refining petroleum. There are only four distinct types of refineries as enumerated in the body of the book and where the pieces of equipment differ one from the other in parallel plants, is due chiefly to the respective owner through his choice of selection. Describing specific Manufacturers' products is done only to establish a standard by which to judge other goods, as the standards prescribed have satisfactorily endured the severe test of time.

Inasmuch as this is the first work of its kind devoted exclusively to the proper materials to be used in the construction or renovation of petroleum refining plants and filling stations, no apology is deemed necessary for introducing it to the public, except, in so far, as its imperfections may demand one. In this respect, the author can only request the reader's indulgence and ask him to make due allowance for any shortcomings he may detect, and to bear in mind the difficulties which are inseparable from a compilation of this pioneer work.

It may be this treatise will serve the purpose of a stepping stone until the time arrives for the publication of a thoroughly comprehensive work. Nevertheless, it is the author's belief that every engineer, designer or student will find something to benefit him in this volume. Should this be true, the author shall feel more than repaid for the effort involved herein.

Grateful acknowledgment is here made of the valuable assistance given the author in the compilation of this work by Messrs. C. O. Fehl, D. W. Sowers, E. M. Holcombe, I. C. Carpenter, H. P. Westcott, A. Rhodes, F. A. Bean, Donald J. Bergmann, James R. McComas and Colonel B. W. Dunn.

A. L. NUGEY.

Perth Amboy, N. J.
November, 1923.

CONTENTS

LIST OF ILLUSTRATIONS

ABBREVIATIONS OF SYMBOLS.

A. A. S. M.	=	Association of American Steel Manufacturers.
Amer. C. I. Pipe Co.	=	American Cast Iron Pipe Co.
Approx.	=	Approximate.
A. S. C. E.	=	American Society of Civil Engineers.
A. S. M. E.	=	American Society of Mechanical Engineers.
A. S. T. M.	=	American Society for Testing Materials.
A. W. W. A.	=	American Water Works Association.
Bbl.	=	Barrels.
Bé.	=	Baumé degrees.
B'l'dg.	=	Building.
B. T. U.	=	British Thermal Units.
C. I.	=	Cast Iron.
Col.	=	Column.
C. S.	=	Cast Steel.
Cu.	=	Cubic.
Cyl.	=	Cylinder.
° F. or deg. F.	=	Degrees Fahr.
Dia. or diam.	=	Diameter.
D'w'g.	=	Drawing.
F. & D.	=	Faced and Drilled.
F. B. P.	=	Final Boiling Point.
F'ce.	=	Furnace.
F'd'n.	=	Foundation.
Flgd.	=	Flanged.
F. S.	=	Forged Steel.
Ft.	=	Feet.
'	=	Feet.
Gal.	=	Gallon.
Galv.	=	Galvanized.
H. P.	=	High Pressure.
H. P.	=	Horsepower.
Hr.	=	Hour.
I. B. B. M.	=	Iron Body Bronze Mounted.
I. B. I. M.	=	Iron Body Iron Mounted.
I. B. P.	=	Initial Boiling Point.
In.	=	Inches.
"	=	Inches.
Incl.	=	Inclusive.
J. M.	=	Johns-Manville.
Lb.	=	Pounds.
Lb./"	=	Pounds per Sq. Inch.
L. P.	=	Low Pressure.
Mall.	=	Malleable.

Max.	=	Maximum.
Min.	=	Minimum.
M. H.	=	Man-Head.
No. or Nos.	=	Numbers.
O. D.	=	Outside Diameter.
O. H.	=	Open Hearth (Steel).
O. S. & Y.	=	Outside Screw and Yoke.
Oz.	=	Ounces.
P. D.	=	Pressure Distillate.
Press.	=	Pressure.
Rad.	=	Radius.
R. H.	=	Receiver House (Sometimes Termed Tail House).
R. P. M or r. p. m.	=	Revolutions Per Minute.
ϕ	=	Round.
S. E.	=	Screw End.
Sp. gr.	=	Specific Gravity.
Sq.	=	Square.
Std.	=	Standard.
Temp.	=	Temperature.
T. S.	=	Tensile Strength.
Ult.	=	Ultimate.
Vel.	=	Velocity.
Vol.	=	Volume.
Wk.	=	Work.
Wrot. I. or W. I.	=	Wrought Iron.
Wrot. S. or W. S.	=	Wrought Steel.
Wt.	=	Weight.
X-Hy. or X-heavy	=	Extra Heavy.
Yd.	=	Yard.
Yr.	=	Year.

TYPES OF REFINING PLANTS.

The Topping Plants (See Fig. 2A).—In some parts of California and Mexico, some of the crude oils are used straightly as fuel oil, while others, contain comparatively small percentages of light fractions, that must be distilled off in order to obtain fuel oils with flash points that can safely be handled. In order to distill off these lighter fractions, refineries termed topping plants are constructed, which consist of either horizontal cylindrical stills or pipe stills made up of continuous pipe coils through which the crude is pumped continuously. The chief product of these plants is fuel oil, although the distillate or overhead stock contains varying percentages of gasoline, naphtha or kerosene, depending of course on the characteristics of the crude. This distillate is usually refined and blended with casinghead gasoline, or it may be sold to other refineries without treatment. Topping plants are most generally operated by producers or pipe line transfer corporations, to dehydrate the crude or for distilling off these light fractions before pumping the crude to tanks farms for very lengthy storage periods. Therefore, the main purpose of topping plants is to to dehydrate the heavy crude oils and to produce satisfactory fuel oil.

The Skimming Plants (See Fig. 1A).—The type of refining plants very common throughout the mid-continent field are termed skimming plants. The purpose of these plants is to distill off only the light fractions from the crudes, such as gasoline, naphtha, kerosene, gas oil and fuel oil, and are therefore not intended for the production of a complete line of derivatives from the heavy residuum. These plants are usually found near the producing fields, especially where the crude oils having a high gasoline content are found. These plants are easily convertible into refineries capable of producing a complete line of lubricating stocks, and in a majority of cases they have eventually been changed into complete run-down refineries, by installing the necessary rerun stills, and equipment for extracting the paraffin wax and the subsequent treatment and filtration of the heavier distillates.

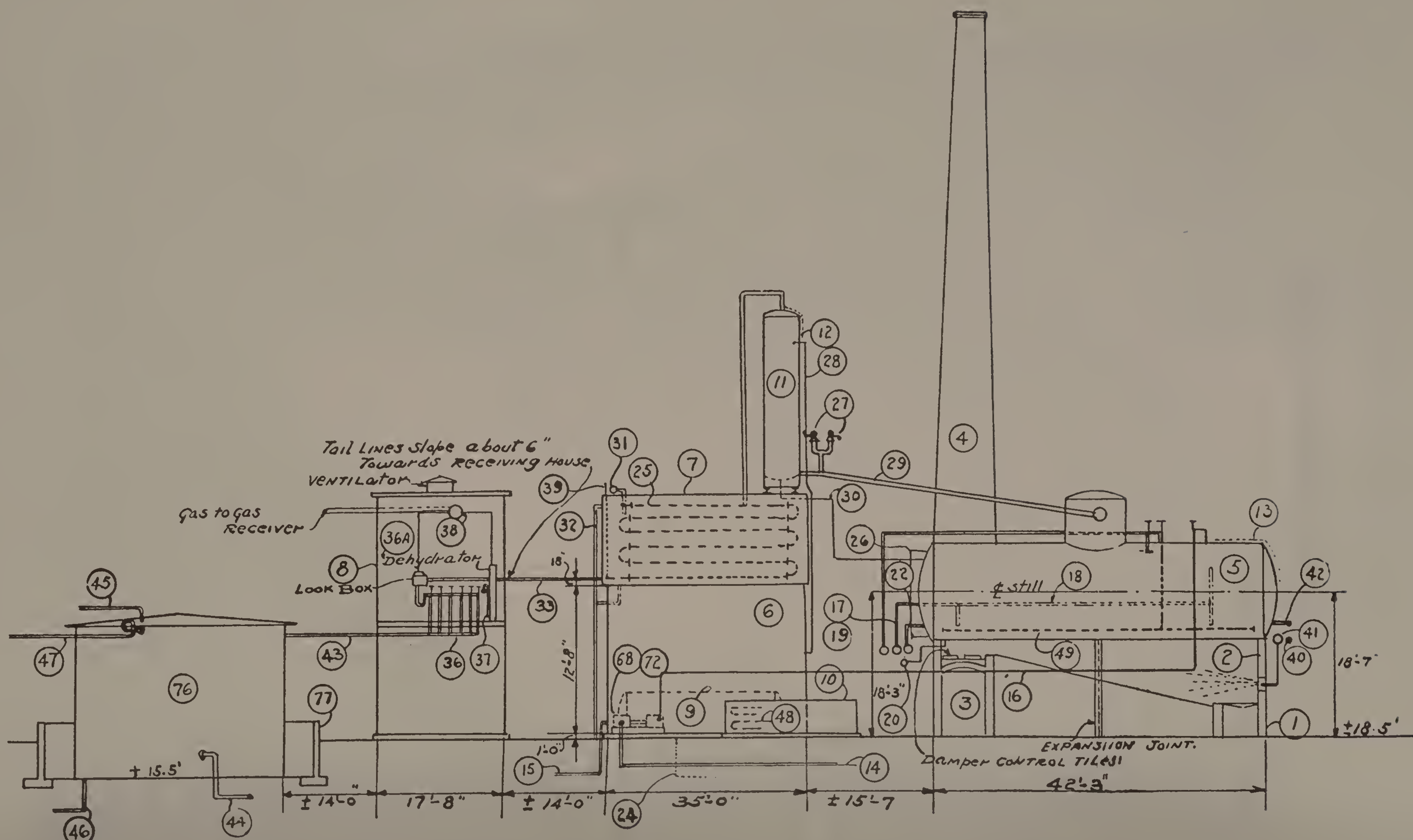


Fig. 1.
Typical cross-section of a crude oil distilling plant. (Typical cross-section of rerun stills is identical.)

The Complete Run-Down Refineries (See Figs. 1 and 2, 4 and 7).—Oil refineries capable of producing a complete assortment of lubricating oils beside the usual products manufactured by skimming plant are termed complete run-down refineries. Very nearly all of the large refineries (and also a number of small ones especially those in the Pennsylvania region) belong to the above classification. Complete run-down refineries most generally locate near the terminal of the trunk pipe lines, or are operated by corporate interests that control the production of crude oil in order to be assured of an abundant supply of crude at all times.

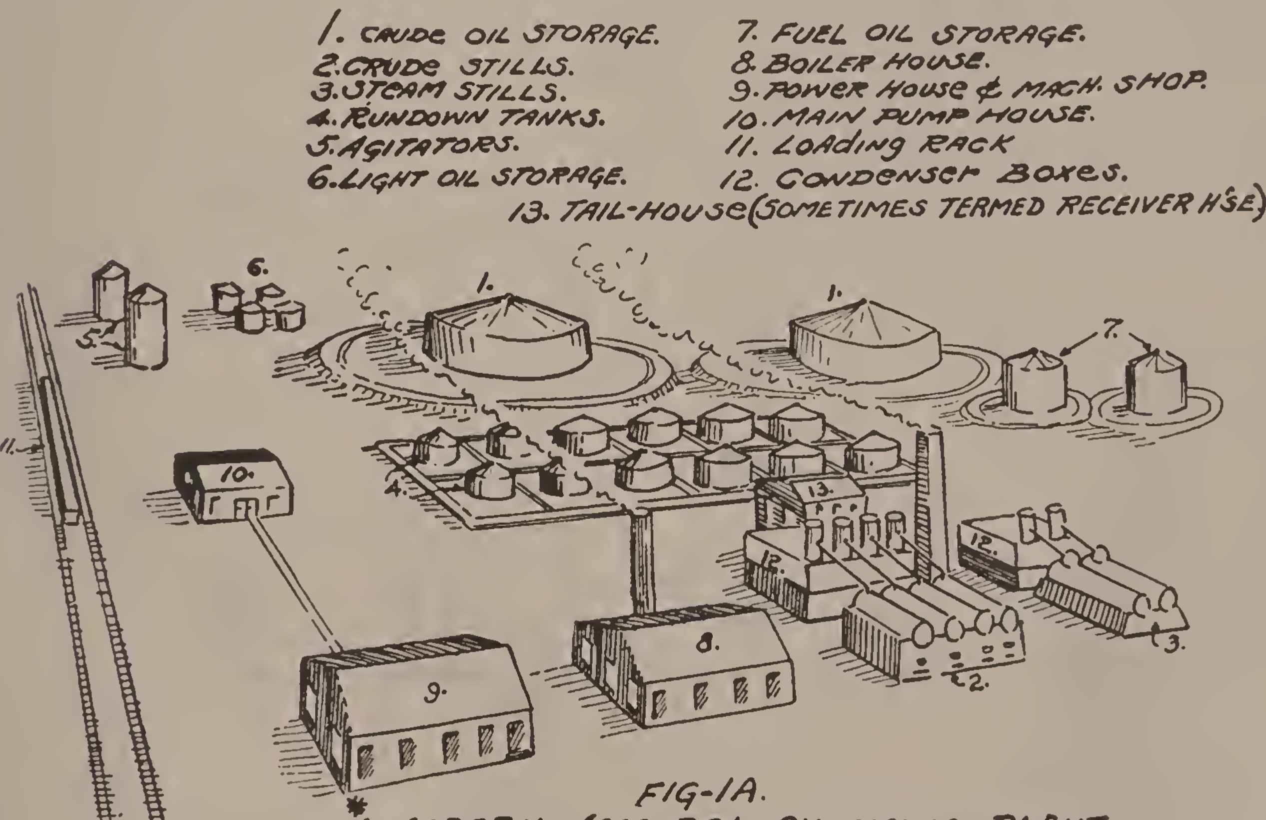


FIG-1A.
A MODERN 4000 BBL. SKIMMING PLANT.

Specifications for equipment same as in Fig. 1.

The Refineries Equipped with Cracking (Units) Plants (See Fig. 3).—Refineries in which gasoline is produced by cracking the heavier hydrocarbons such as gas oil and fuel oil, under high temperatures and pressures are termed cracking units or cracking plants. In some instances cracking plants have been operated in connection with skimming plants, but in most cases complete run-down plants are always equipped with them. Hence, the refineries having these cracking plants not only produce and refine light oils and lubricating stocks, but in addition also increase the production of the gasoline yield from the heavier distillates.

REFINING PETROLEUM.

Petroleum consists of a great variety of various substances, mainly hydrocarbons. These hydrocarbons differ from each other by their gravities and their respective boiling points.

The refining of petroleum consists chiefly in separating these various hydrocarbons, by heat, into groups of similar properties. This is accomplished by charging the crude petroleum into hori-

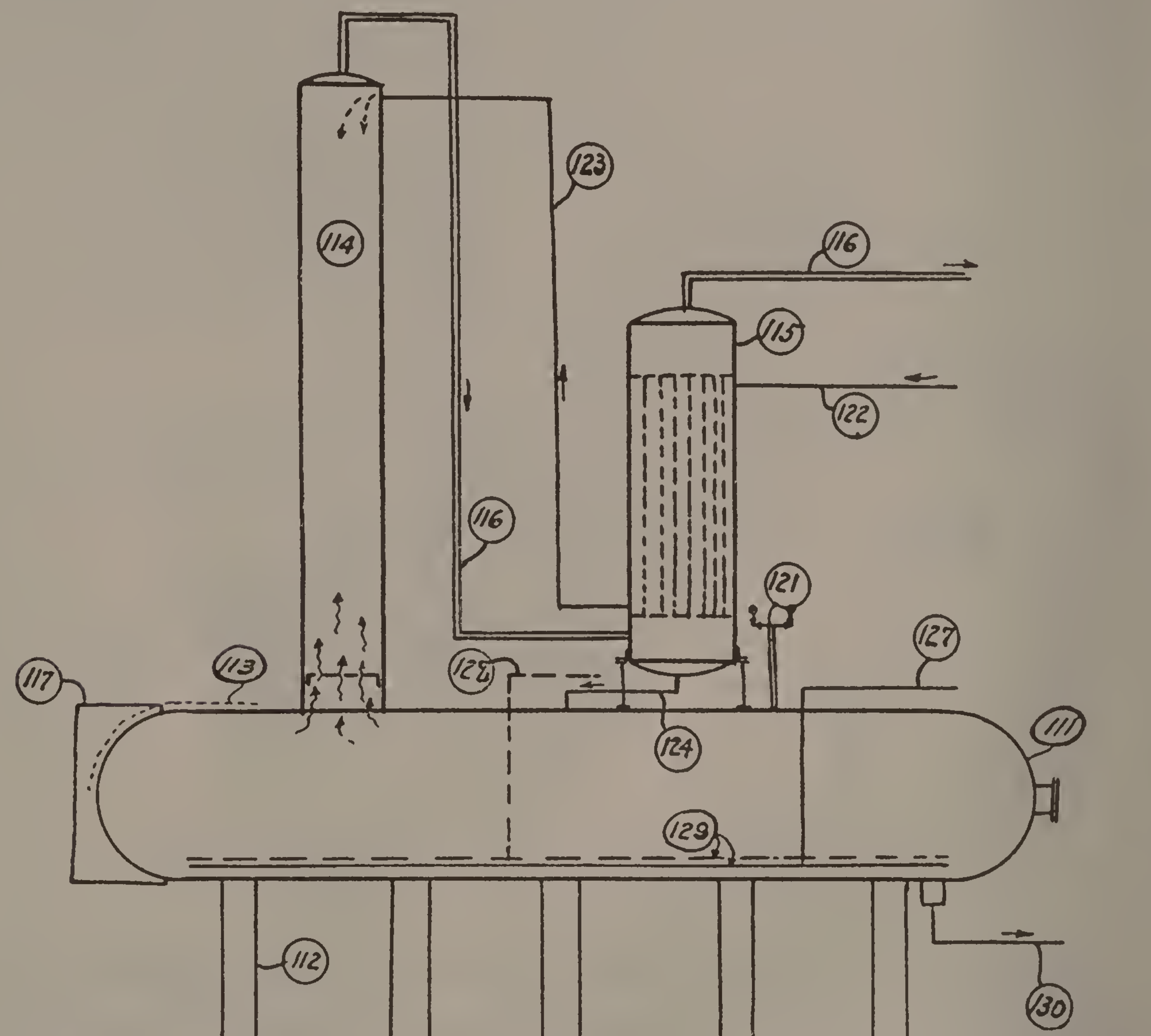


Fig. 2.
Typical arrangement of steam still with auxiliaries.

zontal cylindrical stills usually capable of holding eight hundred barrels of petroleum, which may be the intermittent—usually termed coking stills—or the continuous flowing type.

In the former the crude petroleum is distilled or run down to coke, hence, to separate the hydrocarbons the temperature in the coking stills must be gradually increased until nothing but coke

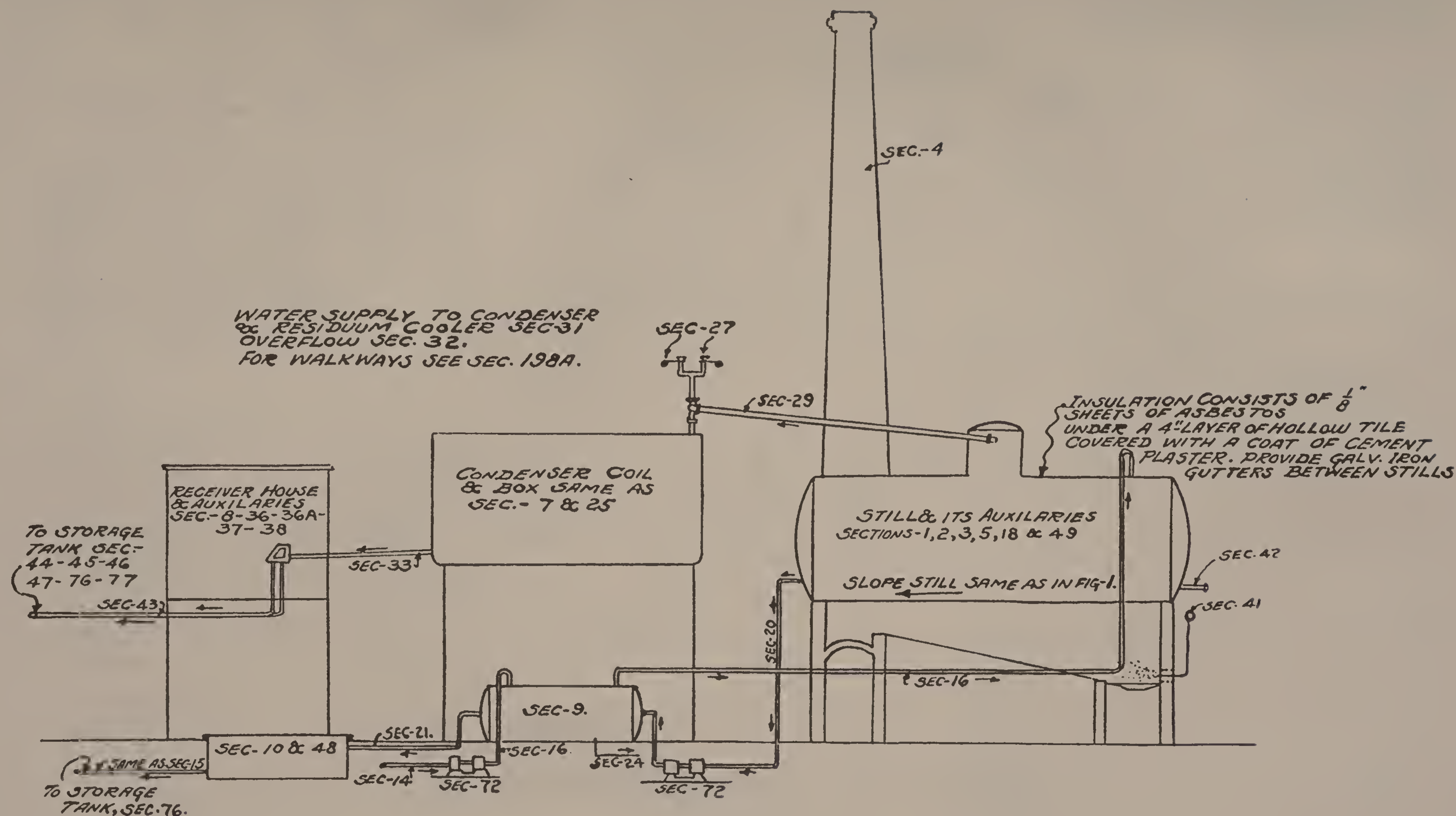


Fig. 2A.
Typical cross-section of a topping plant.

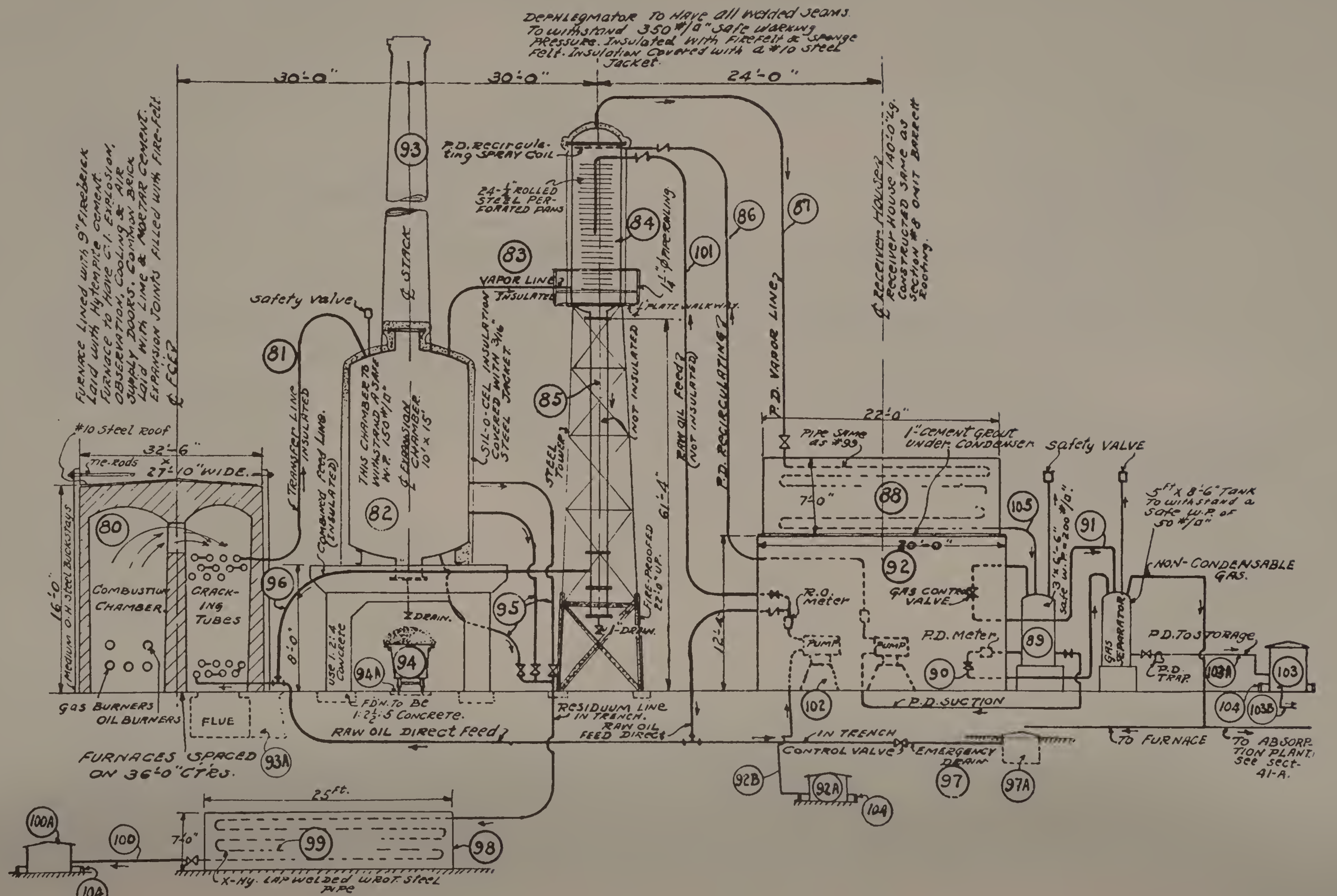


Fig. 3.
Typical layout of Dubbs' cracking plant.

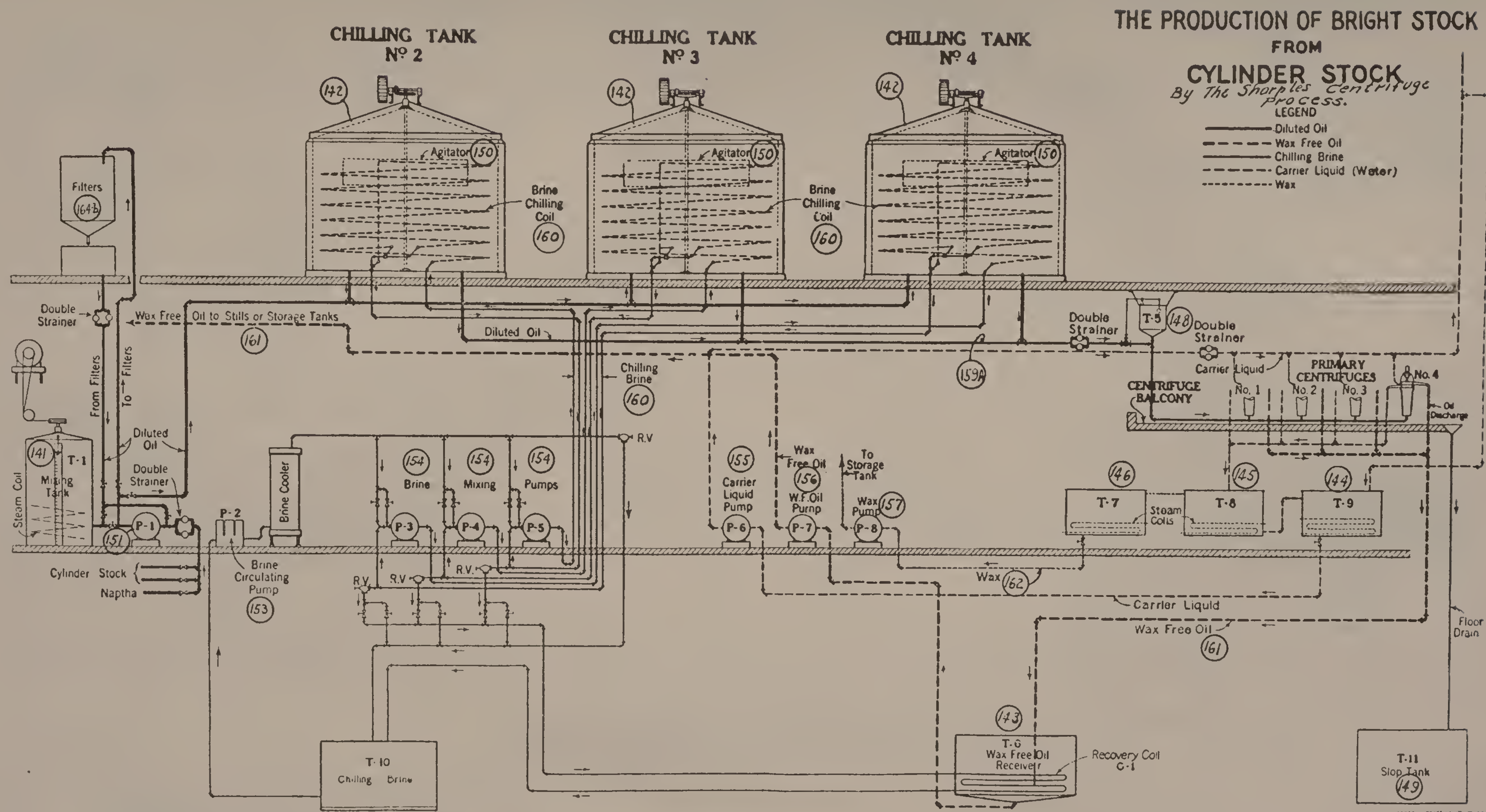
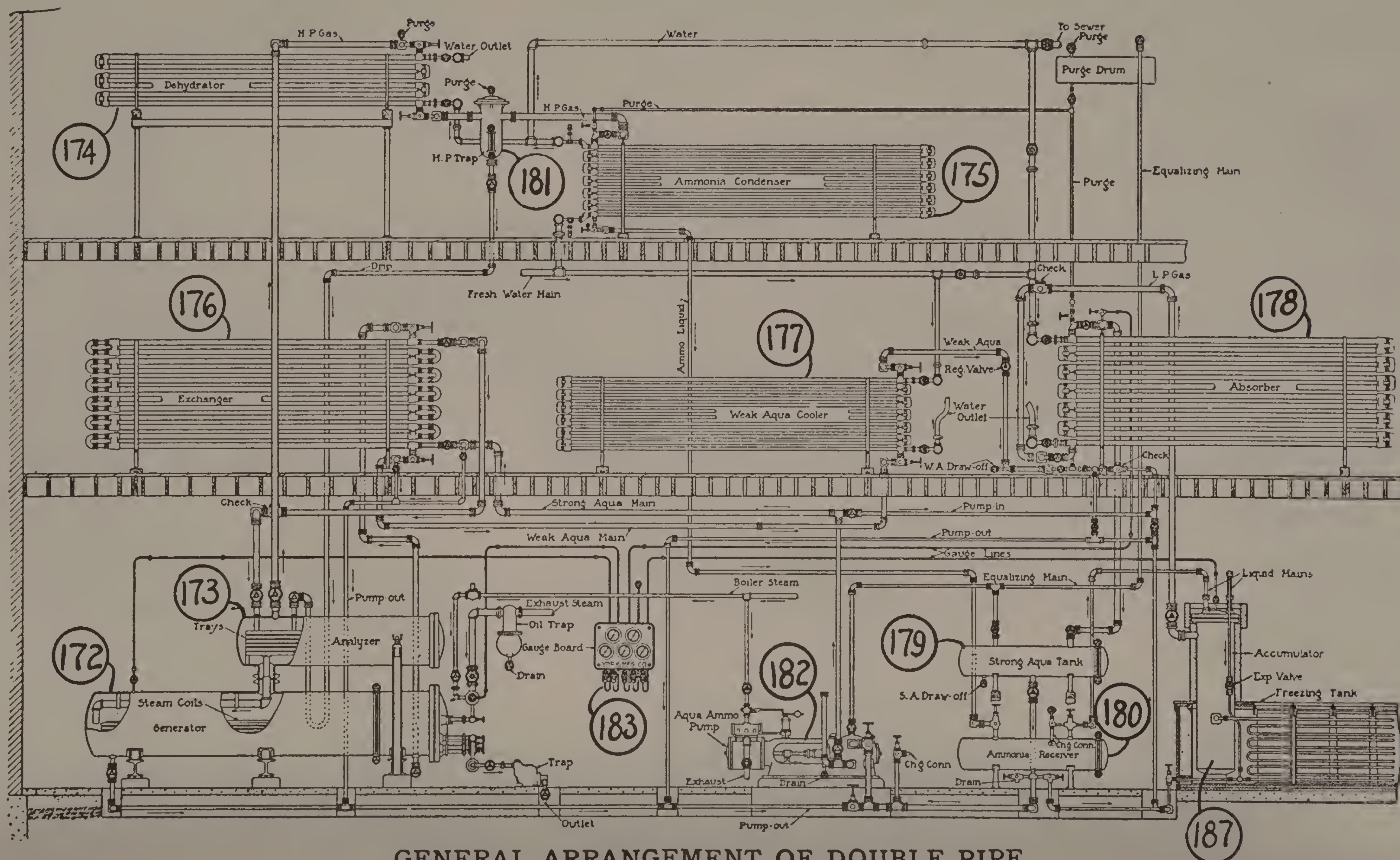

THE PRODUCTION OF BRIGHT STOCK
FROM
CYLINDER STOCK
By The Sharples Centrifuge Process.
LEGEND
Diluted Oil
Wax Free Oil
Chilling Brine
Carrier Liquid (Water)
Wax
CHILLING TANK No. 2
CHILLING TANK No. 3
CHILLING TANK No. 4
142
Agitator 150
Brine Chilling Coil 160
Filters 164B
Double Strainer
Wax Free Oil to Stills or Storage Tanks 161
Diluted Oil
From Filters
To Filters
Chilling Brine 160
T-5 148
Double Strainer
159A
Carrier Liquid
PRIMARY CENTRIFUGES
No. 1
No. 2
No. 3
No. 4
Oil Discharge
CENTRIFUGE BALCONY
141 T-1 Mixing Tank
Steam Coil
P-1 151
Cylinder Stock
Naptha
P-2
Brine Circulating Pump 153
Brine Cooler
154 Brine
154 Mixing
154 Pumps
P-3
P-4
P-5
R.V.
155 Carrier Liquid Pump P-6
Wax Free Oil
156 W.F. Oil Pump P-7
To Storage Tank
Wax Pump 157 P-8
146 T-7
Steam Coils
145 T-8
144 T-9
Wax 162
Carrier Liquid
Wax Free Oil 161
Floor Drain
T-10 Chilling Brine
143 T-6 Wax Free Oil Receiver
Recovery Coil C-1
T-11 Slop Tank 149

Fig. 4.



GENERAL ARRANGEMENT OF DOUBLE PIPE ABSORPTION MACHINE

Fig. 5.

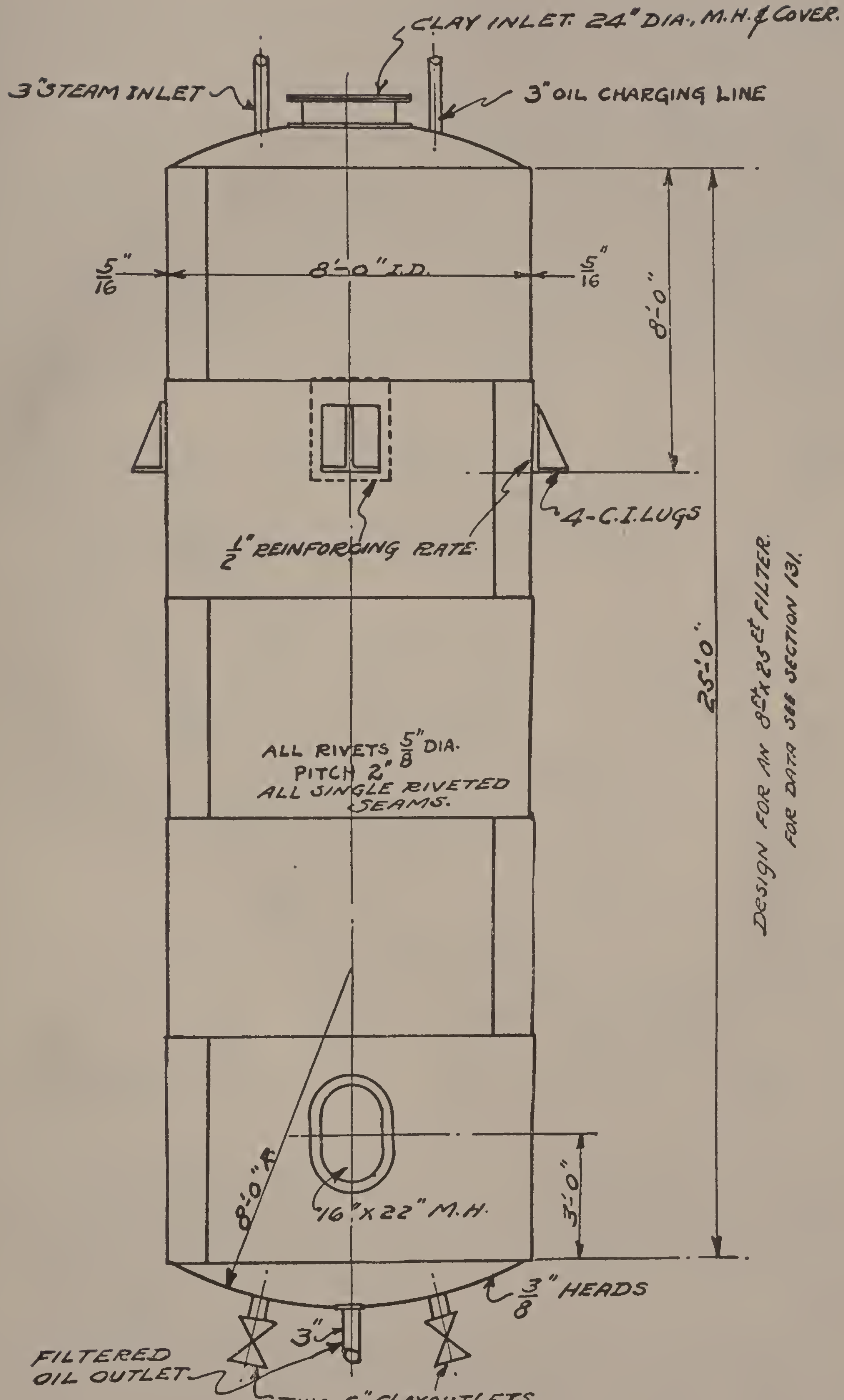

CLAY INLET. 24" DIA., M.H. & COVER.
3" STEAM INLET
3" OIL CHARGING LINE
5/16"
8'-0" I.D.
5/16"
8'-0"
4-C.I. LUGS
1/2" REINFORCING PLATE.
ALL RIVETS 5/8" DIA.
PITCH 2"
ALL SINGLE RIVETED SEAMS.
25'-0"
DESIGN FOR AN 8 Ft. x 25 Ft. FILTER.
FOR DATA SEE SECTION 131.
8'-0" R
16" x 22" M.H.
3'-0"
3/8" HEADS
3"
FILTERED OIL OUTLET
TWO 6" CLAY OUTLETS

Fig. 6.

remains, which, must be removed by manuel labor before the still can be reused. The one advantage, however, favoring the coking stills is that it produces a larger yield of gasoline and kerosene, due to the cracking effect to which the petroleum is subjected. With the continuous stills the petroleum is continuously charged into the first still and continuously overflows into every one coupled in the battery, (which may range from ten to twelve stills per battery). In each still, the temperature is maintained higher than the preceding one, hence, any one still that is maintaining a uniform temperature results in producing a more uni-

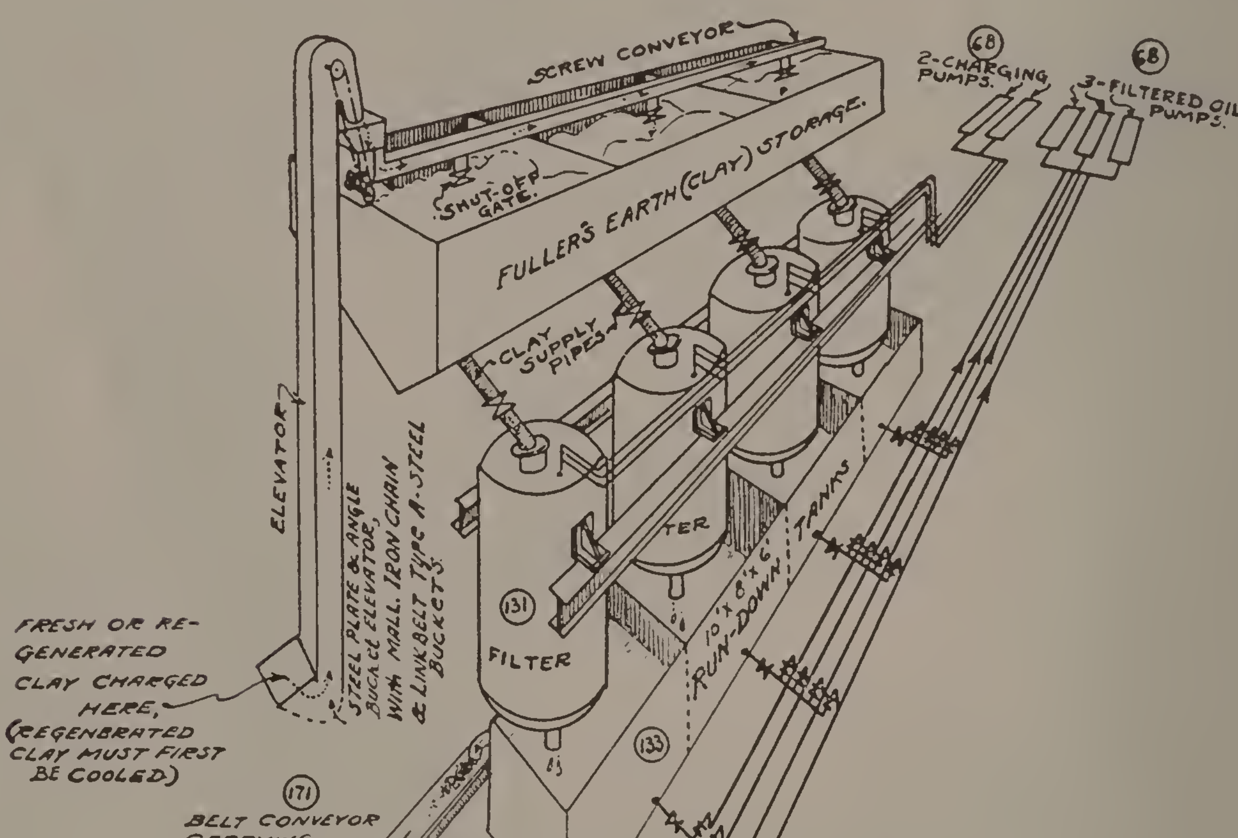
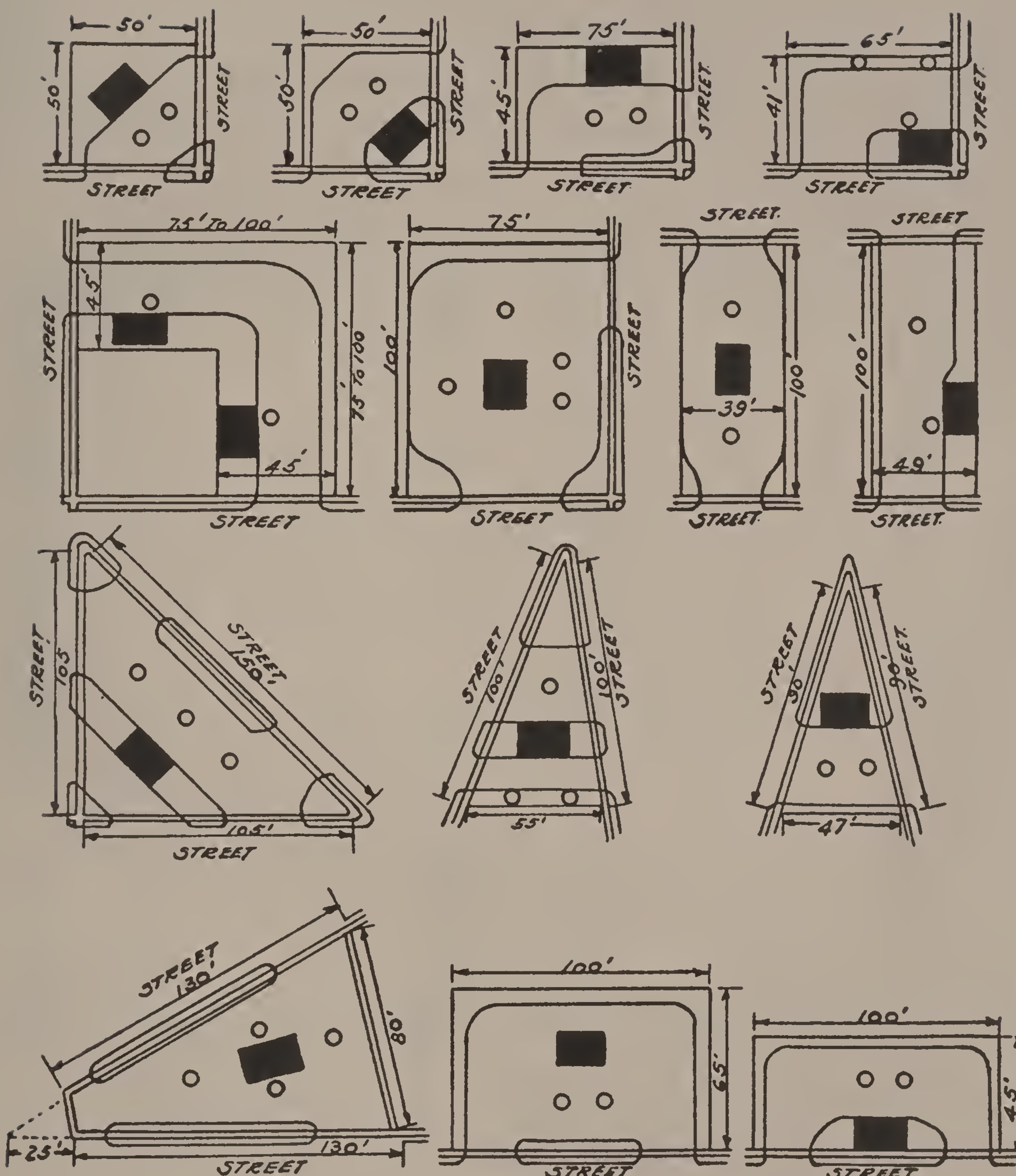


Fig. 7.

form quality of distillate. The advantages favoring the continuous stills are, greater capacities due to no shutdowns necessary for removal of coke, and production of more uniform distillates.

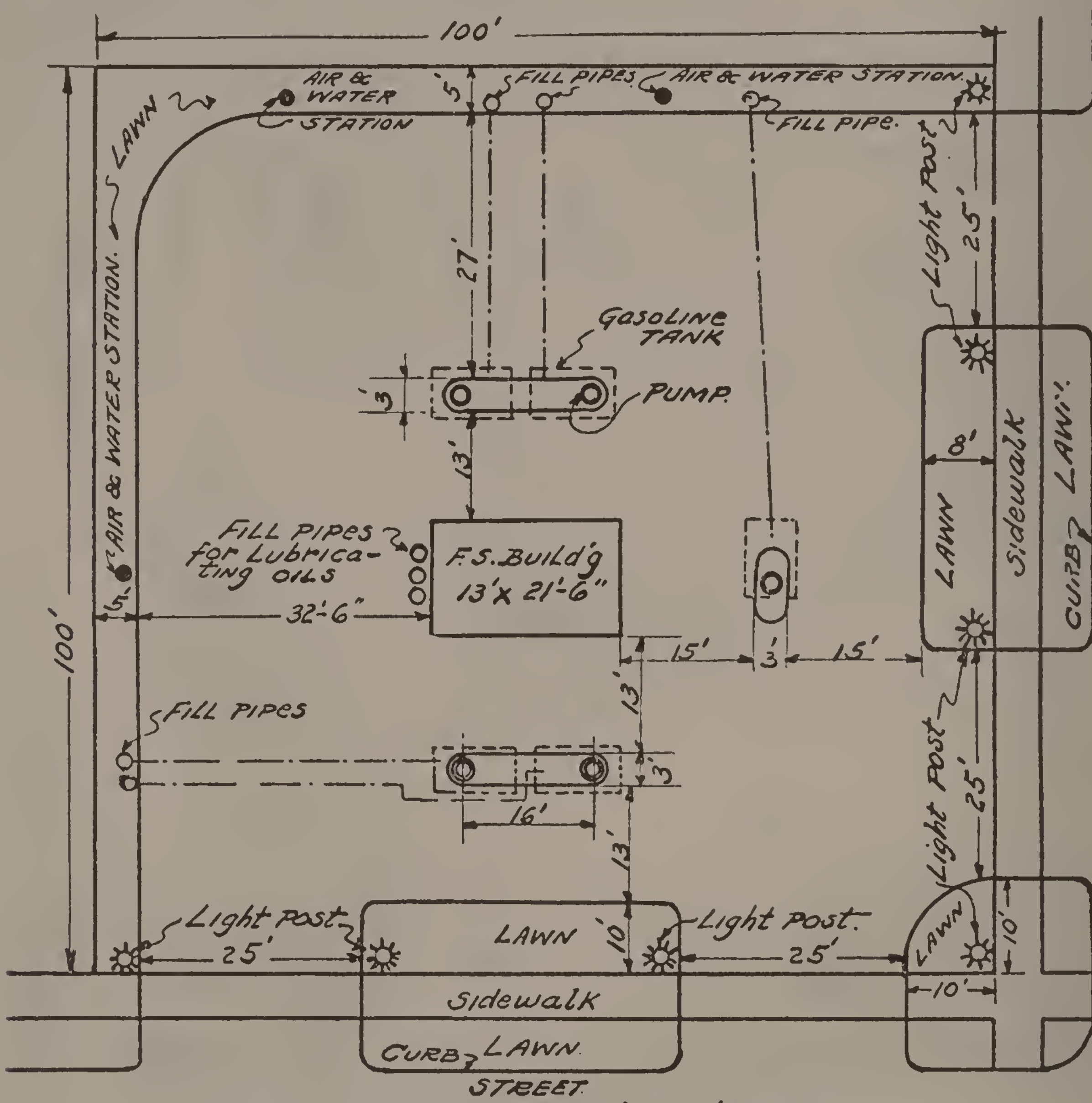
These stills are supported by brick settings, which are heated by fuel oil, natural or artificial gas, or coal. When the temperature rises within the still, the vapors are driven off and pass through the vapor line to the dephlegmator tower, and thence to



Made from a study of approximately 2000 operating stations.
Typical ground Layouts showing minimum size of Lots to which they are applicable. Single driveways are shown as 13ft. wide & double drives are 25 ft. wide. Pump islands are 3ft. wide & buildings 13ft. by 19ft. without covered driveways. Buildings are indicated thus= ; and pumps by-O.

Fig. 7A.

the condenser coil, which is a continuous coil completely immersed in the water held by the steel compartment, termed the condenser box shell. Cold water from the circulating system is continuously supplied to the bottom of the condenser box, while the overflow, at the top of the condenser box, removes the warm water that has already served its purpose. The condensed vapor (now a



Typical Ground Layout for a Large LOT

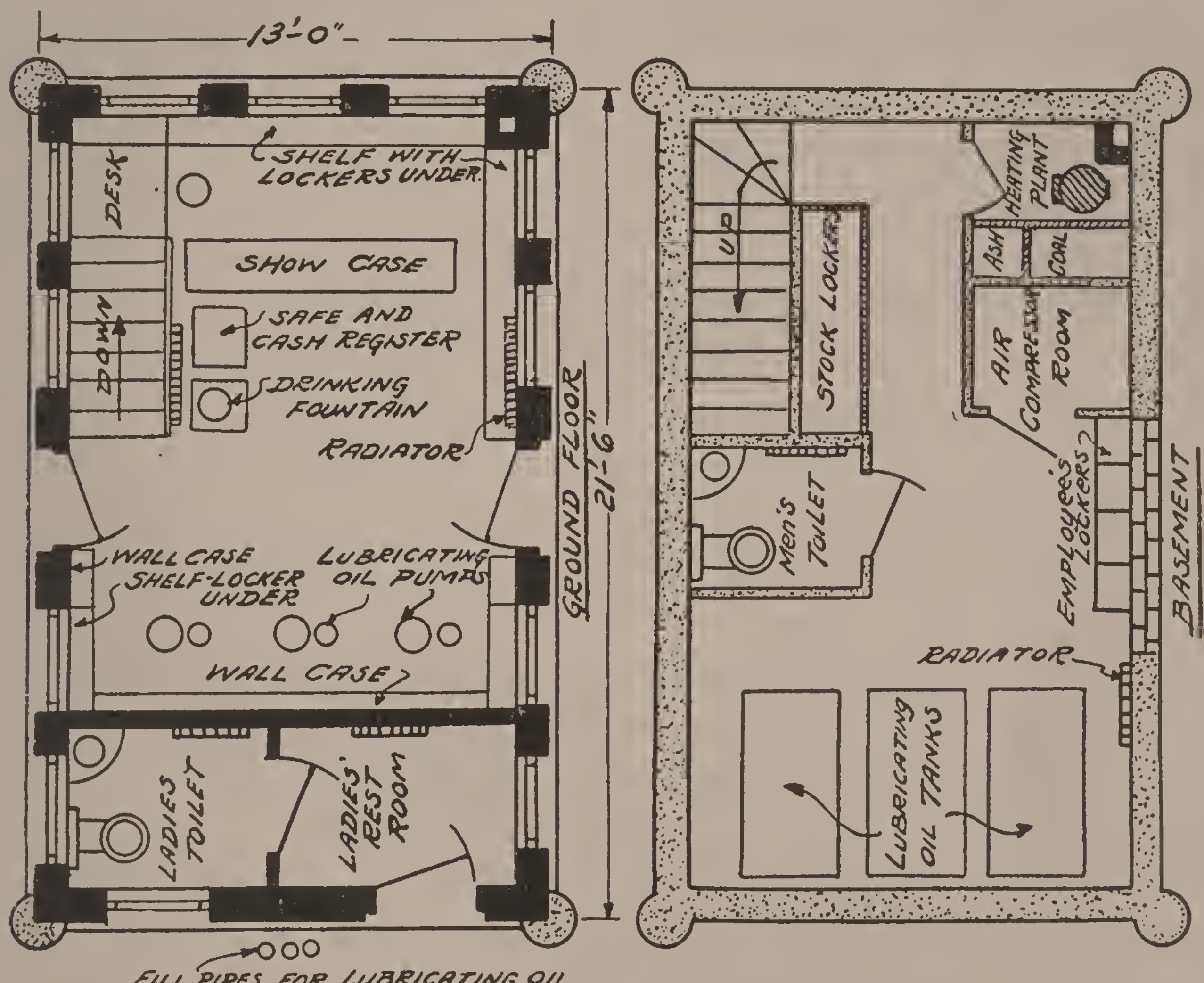
Fig. 7B.

liquid distillate) flows by gravity in through the tail lines to the receiver house, where, the still-man manipulates the various cut-off valves in the manifold and directs the flow of the various distillates into the proper run-down storage tanks.

The crude naphtha is pumped from these run-down tanks into the agitator in which it is treated with sulphuric acid, washed

with water and neutralized with caustic soda, after which it is fractionated in steam stills into the various marketable grades of gasoline and naphtha.

Kerosene distillate is the next product obtained after the crude naphtha and is treated similarly to gasoline. The undesirable sulphur content is removed by treating the kerosene distillate with a solution of lead oxide and sodium hydroxide.



FLOOR PLAN & BASEMENT SHOWING A GOOD WORKING ARRANGEMENT OF FIXTURES & EQUIPMENT.

Fig. 7C.

The next product after kerosene distillate is gas oil, which is heavier and more viscous than the kerosene distillate. Gas oil may be marketed without further treatment as it may be used for enriching carbureted water gas, or in the operation of Diessel oil engines. Most refineries are now equipped with cracking plants, which subject the gas oil to high temperature, thereby crack this heavy oil into lighter products with respective lower

Dx

boiling points and after redistillation, eventually increase the gasoline and kerosene yield. The decomposition of the heavy oils is influenced by numerous factors such as temperature, time, quality of the stock and the pressure at which the cracking is carried on.

The residuum or bottoms from these cracking plants are used as fuel oil either by itself or mixed with other products.

The product obtained after gas oil is known as paraffin distillate, while the residue left in the still is cylinder stock and may be marketed as treated or untreated cylinder stock. It is the paraffin distillate that is the basis for the production of paraffin wax and other lubricating oils, the latter when compounded with other oils, produce a variety of products with special properties suitable for any desired service.

In order to make a complete line of lubricating oils, the wax is removed from treated cylinder stock by the cold settling process and then filtered until a bright color is obtained. By blending these bright stocks with viscous, non-viscous, together with animal or vegetable oils a complete line of lubricants is obtainable.

The process of elimination and purification of paraffin wax may be described briefly as: chilling the oil to cause the solidification of the wax present, filtering under high pressures, treating and sweating and finally melting and filtering through fullers' earth filters. This oil is then ready for the market as soon as formed into commercial-sized cakes.

In conclusion the above article covers briefly typical complete petroleum run-down plants.

POINTS TO BE CONSIDERED IN THE CONSTRUCTION OF OIL REFINERIES.

(A) The availability of obtaining enough crude oil to operate the refinery at full capacity.

(B) Where and what market is open to absorb the refined products?

(C) Shipping facilities for refined products and crude oil should be carefully studied, in order to reduce the transportation rates to a minimum.

When the above three points appear to fulfill the requirements satisfactorily, it is safe to consider the location of the future oil refinery.

Naturally, sufficient funds to cover the cost of the refinery erection and maintain its operation should be available. The funds may be obtained by parties specializing in drafting prospectus and selling stock or by offering good securities as collateral.

The engineer to whom the refinery layout is entrusted should be an experienced technical man, familiar with oil refinery practice; clients will receive more for their money when they employ the services of a competent engineer entirely disregarding his rate of remuneration.

His duties are to compute the essential refinery equipment, such as proper number and size of storage tanks for water and oil, stills, boilers, condensers, electrical equipment, pumping machinery, prime movers, agitators, loading racks, wax plants, steam and oil lines, heat exchangers, sewage and buildings. After the plant is about to operate, the original estimates should not be changed materially. In addition the engineer should be able to compute the profit which will be derived by running the various crudes by various methods.

When all plans are approved and construction commences, a detailed cost of expenses should be made and continually rechecked by the original estimate.

There are quite a number of details that should be considered to reduce construction operation costs, and that will permit future extensions without considerable revision.

A successful refiner will establish a modern accounting system, that will care for fields, refinery maintenance and sales.

A feature that is indispensable with any refinery is experimental stills of about ten to twelve barrels capacity. There should be an experimental still for each of the following: Crude, rerun, steam and pressure stills. With these stills all guess work or opinions will be eliminated and running a sample through the experimental stills, determines exact results as to the quality and yield of various products from the various crudes.

Skimming crude oil refineries should be planned not only for enlargements, but so that is shall be possible with a minimum expense to install additional equipment to run-down crudes to coke.

An important item to consider is the water supply for boilers, and condensers (see Section 203). To reduce boiler scale, the water used from streams should be treated before being used. Condensers may be supplied by (salt water) rivers by using C. I. coils and mains. All cast iron pipe to conform to the American Water Works standard specifications.

An insufficient water supply may be met by installing water cooling towers and spray ponds that will cool off the water so that it may be used over again in the condensers.

All refineries before construction (see Section 169) should be so designed that they will meet the underwriters specifications which will eventually reduce the insurance rate. This in itself will save a considerable item. Stills, distillation tanks, etc., should be sectionalized.

Portable fire apparatus, steam, and chemicals are the essentials in fighting refinery fires, and should be maintained for use in any emergency. (See Section 170).

Care should be taken to provide for the personal safety of all employees, such as well ventilated buildings, the necessary walkways, and danger signs written in a number of languages. Proper lockers and lunch rooms should be provided, any contaminated water should be distilled in small stills and working conditions should be as nearly perfect as possible.

Still settings should be designed so that the maximum B. T. U.'s may be utilized. (See Section 2).

As much waste heat as possible should be saved by using vapor and residuum heat exchangers. (See Sections 9 and 115).

All stills should be covered with good insulation (see Sections 13 and 113). Have ample condensing area in condenser coils. (See Section 202).

A counter current and free flow of the condenser water must be provided.

To prevent oil pollution of streams and harbors (which is legislated against) with waste oil and in addition to save considerable money a water separator must be installed. (See Section 166).

Separate sanitary and oil sewers; oil sewers to lead to a water separator should be built. (See Section 167).

The location of oil transfer pumps should be carefully considered and as many as possible should be placed in the main pump house, to efficiently control same. (For specifications of Manifold Piping see Section 54).

All piping under the soil around the stills should be kept in trenches as it will rust rapidly due to the alkali that may be present in the soil.

(1) Foundations for Fire Stills.—The mixture of concrete should be 1 : 2½ : 5. Material should conform to the latest standard specifications of A. S. T. M.

One part of Portland cement,

Two and one-half parts of clean, dry sand,

Five parts of crushed limestone to pass 1½″ ϕ ring.

For the ventilation between stills, an arched duct may be provided, or cellu'ar partition hollow tile of the best quality to be vitreous or hard burned, and which should have less than 8 per cent absorption must be installed.

The steel reinforcement that is necessary may be either round or deformed and should conform to the latest standard specifications of A. S. T. M.

At least three explosion doors should be provided in (rear of stills) exterior wall of the waste gas flue.

The still supporting column bases should be provided with proper size steel bearing plates properly anchored in the foundation. The steel columns, supporting stills, should be medium open hearth steel and should be painted with Steel Cote Manufacturing Company's 600° F. heat-resisting paint or its equal.

(2) Brick Settings for Fire Stills.—Linings are to be constructed of first quality fire clay bricks standard size (9″ x 4½″ x 2½″). Other special shapes and damper control tile should be first quality clay products equal in refractoriness to the fire brick itself. The batter of the hearths' vertical walls should be about $1^{15}/_{16}$″ per each foot in height, and the lining should be bonded to the red brick backing at every fourth course.

The fire clay should be a fine ground fire clay equal in refractoriness to the fire brick itself.

Exterior walls are to be constructed of first quality common red brick standard size (8″ x 2¼″ x 3¾″).

The lime, cement and sand used should conform to the latest standard specifications of A. S. T. M.

Ferrules cut from standard steel pipe of proper size and number necessary for either the fuel oil or gas burners must be provided and C. I. peep holes (one to each still) and two 12″ x 19″ C. I. draft doors installed.

Red Bricks are to be laid with lime and cement mortar using 1⅛ barrels of lime, ½ barrel of cement and ½ cubic yard of sand per 1,000 red bricks. Every fifth course is to be a header course. The joints are not to be over ⅜″ in thickness and filled solidly with mortar.

Lime is to be slacked one week before using.

Fire Bricks are to be laid with fire clay (and brick dust as a filler) mortar made up of 75 per cent of fine ground fire clay and 25 per cent of brick dust. Fire clay filler to be spread and each fire brick to be rubbed and shoved into final place until it actually touches the brick below. Every fourth course is to be a header course.

Expansion Joints must be provided and filled with indented asbestos roll fire felt ¼″ thick to fill a ¾″ space allowed for ex-

pansion, the fire side of expansion joints is to be pointed with high temperature cement equal to J. M. No. 31 high temperature cement.

As no performance guarantee of any kind is made with the sale of refractories, it is important that all fire brick, special shapes and damper control tiles should be kept in a dry place, as moisture, especially in cold weather will greatly injure them. After completion, the setting should be warmed slowly in order to expel all moisture.

The steel buckstays supporting brick work that are necessary, should conform to the standard specifications of Class "B" steel of the Association of American Steel Manufacturers.

The setting should be constructed so as to give the stills a minimum 3″, or a maximum 4″ slope (towards the rear) per forty feet. This is necessary to facilitate complete draining of still.

(3) Flues for Fire Stills (From Stills to Stack).—The size of the flue is to be as noted upon drawing (specify drawing No.). Flue is to be of reinforced concrete construction with a 4½″ thickness of the fire bricks on the bottom (quality as specified below) while the walls and arched roof (radius of arch to equal width of flue) are to be lined with 9″ thickness of fire bricks. The necessary expansion joints must be provided and fill same with loose fire felt packing. The flue to have a C. I. man-head with cover similar to the Banner Iron Works man-head No. 4781, set in a C. I. extension sleeve.

The mixture of concrete is to be as follows:

One part Portland cement,

Two parts clean, sharp sand,

Four parts crushed limestone to pass a 1½″ ϕ ring.

All reinforcing bars nearest the hot surface are to be spaced one-half of the spacing of outside rods. All rods must be immersed to a depth not less than 2″ from the surface of concrete. The steel reinforcing is to be plain or deformed and must conform to the latest specifications of the A. S. T. M. billet steel.

Fire bricks (used for lining) are to be of best quality of standard dimensions and are to be laid with fire clay and brick dust as a filler, mortar mixture is to be composed of 75 per cent of fine ground fire clay and 25 per cent of brick dust. Fire clay filler is to be spread and each brick to be rubbed and shoved into final place until it actually touches the brick below it. Every fourth course is to be a header course.

(4) Stacks for Fire Stills (Provide One Stack Per Each Battery of Ten Stills) (May be Reinforced Concrete or Perforated Radial Bricks) (For Method of Computing the Size of Stack see Section 218).—The proper foundation will be built by the owner from the plans and specifications furnished by the chimney contractor, who must, upon completion, give a written guarantee that said foundation will sustain the chimney safely. The concrete used should be of the following mixture:

One part of Portland cement,
Two and one-half parts of clean, sharp sand,
Five parts stone or gravel to pass 1½″ ϕ ring.

The concrete should be deposited only in layers of 6 inches and thoroughly rammed into place.

The wall thickness in inches of the brick wall at the bottom of the chimney should be at least equal to

$$7'' + \frac{\text{height of chimney in feet}}{9}.$$

The chimney wall thickness should gradually decrease towards the top to 7″ for 7′0″ diameter chimneys or less; 8″ for chimneys of 7′0″ to 10′0″ diameter, and 10″ for larger chimneys.

The lining should be equal to one-fifth of the total height of chimney where the gas temperature is under 800° F. It should be equal to one-half the total height where gas temperature is between 800 ° F. and 1,200° F.

The batter of the chimney should be about 12″ per every 25 feet in height. All brick work should be laid in cement lime mortar with full joints throughout. The face brick work and backing are to be laid up at the same time and the mortar should

be made of one part Portland cement, two parts fresh burnt lump lime mortar and five parts of clean, sharp sand.

The common brick should have every fourth course a header course, while with radial brick work, it should be bonded at every third course.

Also satisfactory reinforcing rings, chimney coping, cast iron clean out doors, ladder and suitable lightning rods should be provided.

(5) Still Shell.—All dimensions are to be true to and in accordance with the drawing.

The still is to be of horizontal type (specify size). (To determine size of still, see Section 203-A).

The shell of the still is to be fabricated as indicated upon the drawing. (Specify drawing No.) (To determine the thickness of shell see Section 199).

Bottom sheet is to be in one piece and is to be fire box steel.

The heads are to be bumped to the radius equal to the diameter of the still and must be flange steel.

In large stills, channel buckstays must be provided to insure against collapsing pressures.

The still is to have two cast iron manholes complete with cover, located as indicated upon the drawing; also one steel side hill man-head complete with steel plate cover bolted on, and crane (to facilitate removal of cover) located in front head of still.

The still should have (specify number) cast iron lugs (equal number of lugs on each side) each lug to be provided with a $^3/_{16}''$ caulking strip underneath and gun riveted to shell.

Flanges are to be provided where located on drawing and as follows (specify size of flanges):

Side hill flanges in rear of still to be tapped through for a long thread.

- 1 reflux line flange.
- 1 pumping out flange.
- 2 flow line flanges.
- 2 for telltale pipe.

Saddle flanges on top of still tapped through for a long thread. { 1 for charging line. 1 for top steam. 1 for spider steam. }

All flanges are to be forged steel boiler flanges.

One saddle flange for vapor take-off in dome.

The still should be provided with a tar draw-off plug at lowest point in rear of still.

A forged steel boiler flange with standard tapered pipe threads (18″ from bottom of still shell) for thermometer connection should be provided.

The riveting depends upon the size and working pressure of still (but usually are from ¾″ to ⅞″ diameter) all plates are to be neatly and carefully bevel-sheared for inside and outside caulking and the corners are to be scarfed so as to insure tight joints at laps. Stills are to be thoroughly caulked outside and inside and made absolutely tight and dry. (Exceptionally large stills are to be shipped knock down and must be properly match-marked to facilitate erection).

(6) **Condenser Box Settings** may be structural or reinforced concrete, (however, considerable advantages favor the latter, hence, specifications will be written concerning these).

Concrete setting larger than 75′0″ in length should be provided with an expansion joint midway.

Concrete should be 1 : 2 : 4 mixture.

One part Portland cement,

Two parts clean, sharp sand,

Four parts gravel (gravel for beams, slabs and girders are not to be larger than 1″ and for columns and footing not larger than 1½″).

Concrete should be poured continuously for beams, slabs and girders up to expansion joint. Each column should be poured continuously until completed, also beams, girders, slabs and columns should be executed in one pouring.

Steel reinforcing should be (as indicated upon the drawing) plain round or plain square rods conforming to latest standard specifications of A. S. T. M. billet steel.

A 2" thickness of sand cushion (under condenser box) on top of setting should be provided. This sand must be of a clean, hard and coarse nature.

(7) **Condenser Box Shell.**—Material should be in accordance with American Society for Testing Materials standard specifications A-9-21 structural steel for buildings.

Workmanship and details should be in accordance with manufacturer's standard specifications.

All steel is to have one shop coat of approved heat-resisting paint.

All field connections are to be riveted unless otherwise noted.

All rivets and fitting up bolts should be provided with steel work.

All rivets are to be 5/8" diameter unless otherwise noted.

Open holes are to be 11/16" diameter unless otherwise noted.

All joints are to be caulked, all edges to be beveled.

Pipe flanges shown are to be forged steel boiler flanges, standard pipe thread unless otherwise noted.

Field painting is to be one coat of suitable heat-resisting paint.

Shop details are to be submitted for approval.

Condenser boxes are to be made water-tight and proven so by filling one compartment at a time while the adjacent boxes are empty.

Pitch of rivets on all caulked joints are to be (specify pitch desired).

(8) **Receiver House.**—For footings use 1 : 3 : 6 concrete mixture.

For basement pavement use 1 : 1½ : 3 concrete mixture.

For beams, girders and general reinforced concrete use 1 : 2 : 4 concrete mixture.

For grout use 1 : 3 mixture of Portland cement and clean, sharp sand.

(Only Portland cement, clean, dry sand and 1½" ϕ crushed limestone should be used in all concrete mixtures).

All structural steel is to be as per drawing (specify drawing No.) subject to approval, and must be painted with one coat of red lead and oil.

Reinforcement rods are to be as shown on drawing.

Ventilator is to be as shown on drawing. (To determine the number and size of ventilators required, see Section 201).

Steel sash, 3-ply, tinclad sliding door, Feralun saddles and standard 4″ Holt leader connections should be used.

Roof is to be of reinforced concrete construction and covered with Barrett (or equal) 5-ply tar and gravel roofing, 20-year bond complete with all flashings, gravel stops, etc. All lighting conduits are to be placed before pouring concrete.

All necessary C. I. pipe, fittings and hangers should connect leader outlets to drainage system. (For specifications of drainage pipe and fittings see Section 198).

Window sash manufacturer is to furnish cutting schedule to glass contractor, who is to furnish rough wire glass 12″ x 18″ lights and these are to be bonded in steel sash with Wm. T. Baker, Inc., special white steel sash putty.

(9) Specifications for Heat Exchangers (See Section 204).—All dimensions are to be true and in accordance with drawing, (specify drawing No.).

The Association of American Steel Manufacturers standard specifications for plates and rivets should be used.

All plates and heads are to be of open hearth class "A" steel, the tubes to be of best American steel manufacturers' lap-welded soft steel. Tube holes are to be punched ½″ small and reamed to proper size. The sharp edges should be taken off on both sides of the plate. Tubes should be annealed before rolling and are to be prosser-expanded and beaded. All rivets are to be open hearth class "C" 'steel.

Girth joints are to be single-riveted (specify size of rivets and pitch desired).

Longitudinal joints are to be double-riveted (specify size of rivets and pitch desired).

All rivet holes are to be punched $^3/_{16}$″ less than full diameter of rivets, and then drilled or reamed to a finished diameter of not more than $^1/_{16}$″ larger than the rivet with plates and heads bolted in position. After drilling or reaming rivet holes, the plates and heads should be separated and the burrs removed. Rivets

should be of sufficient length to completely fill rivet holes and form head equal in strength to the bodies of the rivets.

All caulking edges should be bevel-sheared or planed for caulking. Caulking should be done with a round-nosed tool. The joints should be made oil and gas tight by caulking only, no foreign substance should be used in joints. The baffles should be carefully fitted to their corresponding head, tube sheet and shell. Gaskets are to be ⅛″ full face, jointless wire inserted asbestos. Shell and heads are to be tested to 100 lb. hydrostatic pressure. In the shop, the metal should receive one coat graphite and oil, and after being completed caulked and tested, the outside surface should be given another coat of graphite and oil.

All workmanship is to be first class. No drift pins should be allowed. The manufacturer should furnish all facilities for inspecting and testing.

(10) Cooling Box Shell.—Cooling box is to be in accordance with dimensions shown on drawing (specify drawing No.).

Material is to be in accordance with the latest specifications of the A. S. T. M. structural steel for buildings.

Workmanship and details are to be in accordance with manufacturer's standard specifications.

All steel work should be given one shop coat of approved heat-resisting paint and after completion another coat of heat-resisting paint. All joints are to be caulked, all edges to be beveled. Pipe flanges shown are to be forged steel boiler flanges. Field coat is to be one coat of a suitable heat-resisting paint.

Shop details are to be submitted for approval.

Cooling box is to be made water-tight.

(11) Dephlegmator Towers.—All dimensions are to be true to and in accordance with the drawing, (specify drawing No.).

The plates and heads are to be open hearth Class "A" steel while the rivets must be open hearth Class "C" steel, conforming to the standard specifications of the Association of American Steel Manufacturers.

The riveting should be determined by the size of the towers.

All rivet holes should be punched $^3/_{16}$″ less than full diameter and then reamed or drilled to a finished diameter of not more

than $^1/_{16}''$ larger than the rivet with plates bolted in position. After drilling or reaming rivet holes, the plates should be separated, and all burrs removed. Rivets should be of sufficient length to completely fill rivet holes and form heads equal in strength to the bodies of the rivets. The plates should be formed cold to exact requirements after punching and beveling.

All caulking edges should be bevel-sheared or planed for caulking, and all caulking should be done with a round-nosed tool. All joints should be made oil and gas tight by caulking only.

Tower is to be caulked inside and outside. Drift pins must not deform metal about the holes. Manhole gaskets are to be ⅛″ full face jointless wire inserted asbestos.

Complete tower is to be tested to (state desired pressure) hydrostatic pressure.

The metal for the tower should be cleaned and outside surfaces are to receive a coat of graphite and oil, and after being completed, caulked and tested the outside surface of the tower is to be given another coat of graphite and oil well worked into every joint.

The tower should have the necessary forged steel boiler flanges, for vapor lines, reflux condensation, etc. Suitable angle iron shelving to support insulation should be provided, also the tower base angle should be (of sufficient size with welded ends) riveted to skirt of tower. This base angle must have a sufficient number of anchor holes by which to anchor tower rigidly.

(12) Dephlegmator Tower Insulation.—The insulation on these towers should be as outlined below:

A 2″ thickness of sponge felt should be laid against the steel shell using broken joints, this sponge felt is to be in sizes of 36″ x 24″ and is to be held in position with girth lines of No. 14 galvanized soft annealed steel wire spaced about 9″ centers and tied to six or eight vertical (No. 14 galvanized soft annealed steel) wires. (The broken joints of sponge felt are to be filled with J. M. No. 302 asbestos cement or its equal. A ¼″ thickness rough coat of J. M. No. 302 asbestos cement should next be applied throughout and upon this ½″ hexagon galvanized chicken wire should be laid. Another ¼″ thickness of J. M. No.

302 cement should be applied and finish with ¼″ mixture of one part Portland cement and two parts of J. M. No. 302 asbestos cement. This must now be painted with J. M. Special Sizing and covered with a $^{3}/_{16}$″ coat of Asbestile Cement.

This insulation should be applied both to the top head and cylindrical surface. The second ¼″ of rough coat applied to the head should be scratched in order to take the finished coat.

(13) Fire Stills Insulation.—The manner of applying the insulation to the bare shell and heads should be as follows:

First, a layer of Sil-o-cel bricks (9″ x 4½″ x 2½″) should be laid up with broken joints to a thickness of 2½″. These bricks are to be held in place with No. 14 gage soft annealed steel wire spaced on 9″ centers at right angles to the Sil-o-cel bricks. Then a ¼″ layer of a mixture of 70 per cent No. 302 J. M. asbestos cement with 30 per cent of Portland cement should be spread over the bricks, and upon this, lay a No. 19 gage 1″ mesh of galvanized chicken wire throughout the complete surface and spread the final ½″ layer of a mixture of 70 per cent No. 302 J. M. asbestos cement with 30 per cent of Portland cement.

The valley gutters between stills are to be properly flashed and made of No. 18 gage galvanized sheet iron. The gutter is to flash over brick work and to extend downward a distance of two brick courses, and secured with 1½″ flashing hooks similar to the "Merchant and Evans'"[1] product or its equal.

The space that is allowed for expansion between the still shell and the brick work should be provided with a 3″ diameter asbestos fire felt jelly roll (made to suit the conditions) by rolling 1″ diameter J. M. No. 4196 commercial asbestos twisted rope in ¼″ thick J. M. asbestos fire felt and tied with J. M. No. 285 asbestos twisted cord on 4″ centers. In order to keep this jelly roll in its proper place a 2″ standard black merchant pipe should be placed behind it.

(14) Suction Lines from Field to Still Charging Pumps Located Under Condenser Boxes.—Random lengths of black merchant pipe with line pipe couplings on one end and thread protectors on the other end should be used.

[1] Merchant & Evans Company.

Fitting are to be medium weight C. I. screwed ends Crane 175 lb. or equal. (See Section 225).

Valves are to be standard flanged gate valves (use only gate valves) I. B. B. M. steel stems and are to be packed for oil. Flanges should be faced and drilled to A. S. M. E. 125 lb. standard dimensions. (See Section 222).

Companion flanges are to be standard C. I. companion flanges faced and drilled to A. S. M. E. 125 lb. standard dimensions. (See Section 222).

Flanged fittings (where necessary) are to be standard C. I., using long radius elbows where possible, fittings are to be faced and drilled to A. S. M. E. 125 lb. standard dimensions. (See Section 222).

Nipples are to be standard black nipples threaded at both ends.

Gaskets should be $^1/_{16}''$ thick, J. M. Seigelite or equal.

(15) Discharge Lines from Still Pumping Out Pumps to Tanks in Field.—Random lengths of black merchant pipe with line pipe couplings on one end and thread protectors on the other end should be used.

Fittings are to be "Crane Oil" mallable iron screwed ends or equal. (See Section 223).

Valves must be medium flanged gate valves similar to Crane 505 or equal, faced and drilled to A. S. M. E. 250 lb. standard dimensions. (See Section 221).

Companion flanges shou'd be X-heavy C. I. companion flanges, faced and drilled to A. S. M. E. 250 lb. standard dimensions. (See Section 221).

Flanged fittings (where necessary) should be X-heavy C. I. flanged fittings faced and drilled to A. S. M. E. 250 lb. standard dimensions. (See Section 221).

Nipples should be X-heavy black nipples threaded at both ends.

Gaskets should be $^1/_{16}''$ thick, J. M. Seigelite or equal.

(16) Charging Lines from Charging Pumps to Exchangers and from Exchangers to Top of Stills.—Black merchant pipe and standard black nipples threaded at both ends should be used.

Fittings shou'd be medium weight C. I. screwed, Crane 175 lb. or equal. (See Section 225).

Standard flanged gate valves O. S. & Y., I. B. B. M. steel stems equal to Crane No. 465 should be packed for hot oil and faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Flanged fittings (where necessary) are to be standard C. I. faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Companion flanges are to be standard C. I. faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Expansion joints not necessary, as jack knife swings will be provided by using the screwed-end fittings.

J. M. Seigelite $^1/_{16}''$ or equal ring-type gaskets should be used on all lines before entering heat exchangers, beyond exchangers use $^1/_{16}''$ J. M. Service ring-type gaskets or its equal.

Covering of hot oil line is to be made by applying 1½" J. M. asbestos sponge felt or equal and this is to be wrapped with 1-ply tar paper and fastened every 6 inches with No. 22 galvanized annealed soft steel wire, or as an alternate cover the insulation with an 8-ounce canvas jacket, applied over 16 pounds asbestos paper sewed on, using three stitches per inch.

A temperature recording thermometer, design as specified in Section 42, and a piston-type meter of an approved design to record volume of oil charged into stills should be provided. Thermometer and meter are to be located between first still and exchanger.

(17) By-Pass Lines at Stills (Used in Continuous Crude Distillation).—Black merchant pipe and standard black nipples threaded at both ends should be used.

The nipples which are screwed into the stills must be X-heavy, one end to have standard pipe threads, the other end to have straight threads (specify length).

Flanged fittings (where used) must be standard cast-steel, faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Screwed fittings should predominate and must be X-heavy mallable iron equal to Crane 600 lb. screwed-end fittings. (See Section 224).

Valves are to be standard gate valves, cast steel body, bonnet and disc, with C. I. yoke, steel stem and nicaloy seats, similar to

Crane 47 B or its equal, the flanges are to be faced and drilled to the A. S. M. E. 125 lb. standard dimensions.

Expansion joints should be used, at least two per each ten stills, and must be special cast steel expansion joints, having cast steel bodies and steel sleeves; the design should be similar to Crane No. 401. They must be packed for hot oil having a maximum temperature of (specify temperature degrees F.), also the standard flanges should be faced and drilled to the A. S. M. E. 125 lb. standard dimensions.

Gaskets must be J. M. $^1/_{16}$″ Service ring-type gaskets or equal.

Covering is to be same as recommended in Section 16.

(18) Flow-In and Flow-Out Lines Inside of Still (For Continuous Stills).—The flow-in line to feed stills should extend to the coolest end, and must be provided with an elbow turned down, while the flow-out line extending to the hottest part of the still must have a vented or open top above the liquid level.

Black merchant pipe on both lines should be used.

Fittings are to be X-heavy mallable iron equal to Crane 600 lb. S. E. fittings. (See Section 224).

Flanged unions (must be used if necessary) should be a pair of standard cast steel flanges faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Both lines are to be suspended (specify distance) from buckstay within still by either a loop made of ¾″ standard chain or the adjustable pipe hangers having extension bar similar to Crane Company's hanger. In case the still is small and does not require any buckstays to prevent collapse, weld a suitable steel hook in roof of still from which the flow-in and flow-out lines may be suspended.

These lines are not to be covered with any insulation.

(19) Flow Line Outside of Still.—Specifications are the same as by-pass line at stills (Section 17).

(20) Residuum or Tar Line from Stills to Heat Exchangers (Rear of Stills).—Specifications are the same as by-pass line at stills (Section 17).

In addition, provide either a 2″ Pratt and Cady standard asbestos-packed screwed cock, or a 2″ (screwed end) Victory FcH

standard cast steel straightway valve, 200 lb. working pressure. Either of these valves should withstand a hot oil temperature of 700° F. as they will be used for draining purposes.

Pipe covering should be the same as for Section 16.

(21) Residuum or Tar Line from Heat Exchangers to Pumps. —Black merchant pipe and black nipples threaded at both ends should be used.

Standard C. I. flanged fittings faced and dri'led to A. S. M. E. 125 lb. standard dimensions should be used.

Screwed fittings (where necessary for jack knife swings) are to be medium weight cast iron equal to Crane 175 lb. (See Section 225).

Valves are to be standard flanged gate valves O. S. and Y. steel stems, I. B. brass trimmings, faced and drilled to A. S. M. E. 125 lb. standard dimensions, similar to Crane No. 465 or equal and must be packed for hot oil.

Companion flanges are to be standard C. I. companion flanges faced and drilled to A. S. M. E. 125 lb. standard dimensions. (See Section 222).

Gaskets are to be J. M. $^1/_{16}$" Service ring-type or its equal.

No pipe covering is necessary on this line.

(22) Pumping Out Line to Cooler Box.—Extra heavy nipples should be used next to still.

The line within the still should extend to the hottest end and should have an X-heavy mallable iron elbow turned down with a make-up piece of pipe screwed in elbow and dropped down to within 18 inches from the still bottom. This line should be supported similarly to the flow-in and flow-out lines under Section 18.

All fitting (except flanged fittings) outside of still shou'd be X-heavy mallable iron screwed ends. (See Section 224).

Flanged fittings and companion flanges (where necessary) should be standard cast steel faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Standard flanged gate valves faced and drilled to A. S. M. E. 125 lb. standard dimensions, cast steel body, bonnet and disc,

C. I. yoke, steel stems and nicaloy seats and dics rings, Crane 47 B or equal should be used.

Expansion joints at stills should be special cast steel expansion joints with cast steel bodies and steel sleeves, design and dimensions must conform as per Crane No. 401 standard flanged expansion joints, faced and drilled to A. S. M. E. 125 lb. standard dimensions and packed for hot oil, having a maximum temperature of 700° F. (Expansion joints beyond stills are to be made by jack knife swings using screwed fittings).

Gaskets are to $^1/_{16}$″ J. M. Service ring-type or equal.

No pipe covering is necessary on this line.

(23) Pumping Out Line from Cooler Box to Pumps Suction.—Specifications are similar to charging lines from charging pumps, to exchangers and from exchangers to top of still (see Section 16) except no insulation is necessary for piping.

(24) Drain Lines from Heat Exchangers.—These drains are to be piped to an oil sump and later collected and reclaimed.

Black merchant pipe and standard black nipples threaded at both ends should be used.

Fittings are to be equal to "Crane Oil" malleable screwed ends. (See Section 223).

Unions are to be malleable iron navy unions Crane No. 98 E or equal.

Bushings are to be black malleable iron shoulder bushing.

Valves are to be screwed end, iron body, iron mounted, clamp type Crane No. 488 or equal and must be packed for oil.

Exchanger is to be provided with a satisfactory pressure gage, 2″ relief valve and a 2″ (check) vacuum valve.

(25) Condenser Box Coil.—Sterling oil condensing sections (as manufactured by American Radiator Company or its equal) should be used.

Simplex cast iron "Class A" pipe with simplex cast iron return bends and cast glands (as manufactured by American C. I. Pipe Company) should be employed for use on heavy condensing worm.

Standard C. I. flanged or special cast iron flanged fittings (if necessary) faced and drilled A. S. M. E. 125 lb. standard dimen-

sions should be used. These may be used either above or below condenser water level. (See Section 231).

Standard C. I. flanged "Class A" pipe (A. W. W. A.) (when under water) and standard lap-welded soft steel pipe with standard C. I. companion flanges for use above water level should be used. (The flanges in both cases are to be faced and drilled to A. S. M. E. 125 lb. standard dimensions).

Pure asbestos ring gaskets for simplex pipe flange joints should be used.

Manufacturer's asbestos composition gaskets for sterling oil condensing sections should be used, in other cases use J. M. $^1/_{16}''$ Service ring-type gasket throughout or its equal.

(26) Gauge Column or Telltale Pipe in Rear of Stills.—This telltale pipe is usually 1½″ in diameter.

X-heavy nipples and pipe should be used throughout.

Fittings are to be screwed-end X-heavy malleable iron recessed and having long threads, equal to Crane 600 lb. (See Section 224).

Pipe plugs (if necessary) are to be for X-heavy malleable iron recessed S. E. fittings.

Valves, for trial cocks, spaced on 12″ centers are to be ⅜″ rough plain Bibb-Cocks screwed ends Crane No. 800 or equal.

Valves, for draining telltale, are to be ½″ asbestos packed cock screwed-end Crane No. 310 or equal.

Valves, to cut off telltale with still, are to be Victory FcH standard cast steel, screwed ends straightway valves, 200 lb. working pressure to be used for hot oil having a maximum temperature of 700° F.

Unions are to be ground joint unions screwed ends Crane navy No. 98 E or equal.

(27) Vacuum and Safety Valves on Stills.—Nipples are to be standard soft steel lap welded pipe nipples.

Fittings are to be X-heavy malleable iron screwed Crane 600 lb. or equal. (See Section 224).

Vacuum valve is to be equal in quality to National[1] B-1143.

Safety valve is to be equal in quality to National[1] B-1142.

[1] National Supply Companies.

(28) Dephlegmator Tower Wash Lines and Manifold.—Black merchant pipe and standard black nipples, standard threads at both ends should be used.

Fittings should be medium weight cast iron Crane 175 lb. or equal. (See Section 225).

Union ground joint lip unions should be used.

Screwed-end clamp gate valves, iron body, brass mounted Crane No. 490 or equal should be used.

A temperature recording thermometer, design as specified in Section 42, and a meter of an approved design should be provided. These are to be located in each individual tower wash line.

(29) Vapor Lines from Stills to Dephlegmator Towers and from Towers to Condenser Coil Inlet.—Standard soft steel lap welded pipe should be used.

Standard black nipples should be used except in dome of still, for which use standard soft steel lap welded nipples.

Fittings (screwed fittings should predominate to facilitate swinging due to expansion of pipe) are to be X-heavy malleable iron Crane 600 lb. or equal. (See Section 224).

Flanged fittings and companion flanges (where necessary) are to be standard cast steel faced and drilled to A. S. M. E. 125 lb. standard dimensions.

A temperature recording thermometer, design as specified in Section 42, should be provided in each of the vapor lines leaving each tower.

(30) Run Back (or Reflux) Line from Dephlegmator Towers to Stills.—Black merchant pipe should be used.

Standard black nipples should be used, except those entering into towers or still, these must be X-heavy nipples.

Fittings (screwed fitting must predominate) should be "Crane Oil" (Section 223) malleable S. E. fittings at towers and X-heavy malleable iron (Section 224) equal to Crane 600 lb. around the still.

Unions are to be standard ferro-steel companion flanges faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Flanged fittings and companion flanges (where necessary) are to be standard cast steel faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Valves (at stills) are to be standard flange gate valves cast steel body, bonnet and disc. C. I. yokes, steel stems and nicaloy seats and disc rings faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Valves (at towers) are to be screwed gate valves, iron body, brass mounted, clamp type packed for oil Crane No. 490 or equal.

Gaskets are to be J. M. Service $^1/_{16}''$ ring-type or equal.

Expansion joints (in main header in rear of stills) are to be special cast steel expansion joints with cast steel bodies, steel sleeves, design and dimensions equal to Crane No. 401 standard flange expansion joint, faced and drilled to A. S. M. E. 125 lb. standard dimensions and packed for oil having a maximum temperature of 700° F.

(31) Water Lines to Condenser Box and Residuum Cooler (Using Fresh Water Only).—Black merchant pipe and standard black nipples threaded at both ends should be used.

Fittings (leads to each compartment) are to be medium weight screwed ends cast iron Crane 175 lb. or equal. (See Section 225).

Standard screwed-end gate valves, iron body, brass mounted with renewable hard metal seats and disc should be used.

(When salt water is used for cooling purposes use cast iron pipe).

(32) Overflow from Condenser Box and Residuum Cooler to Circulating Water Sewer.—Black merchant pipe should be used.

Fittings are to be medium weight cast iron screwed Crane 175 lb. or equal. (See Section 225).

Unions are to be C. I. companion flanges faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Gaskets should be $^1/_{16}''$ thick, J. M. Seigelite ring-type or equal.

(33) Tail Lines from Condenser Boxes to Receiving House.—Pipe is to be standard black merchant.

Nipples are to be standard black nipples threaded at both ends.

Fittings are to be Crane "Oil Mall." iron screwed ends or equal.

Flanged fittings and companion flanges (if necessary) are to be standard C. I. faced and drilled to A. S. M. E. 125 lb. standard dimensions.

These tail lines are usually enclosed (boxed up) in a wooden or a frost proof box to prevent freezing during winter months.

(34) Asbestos Specifications for Heat Exchangers.—In covering the heat exchangers with 21″ x 36″ x 2″ thick sheets, these sheets will be laid up against the heat exchangers, with the 36″ dimension parallel to the center line horizontal of the equipment. These slabs will be wired on tightly with galvanized wire with about four wires per each 36″ in order to hold the asbestos directly in contact with the shell of the equipment.

Next the joints formed by the junction of these sheets will be filled in with an asbestos putty, and the heavy duck canvas will be pasted over the sheets with a flour and water paste, and also wired in place in the same way as the asbestos sheets underneath.

The heavy duck canvas will then be given two coats of red lead paint and a finish coat of a good quality of black paint.

(35) Asbestos Specifications for Vapor Lines.—Vapor lines to dephlegmators, and between dephlegmators should have a 1″ covering.

The covering will be installed over the pipe and the junction canvas pasted in place with a flour and water paste. This covering will be tightly wired to the pipe by three galvanized wire loops per each joint of covering.

Next the asbestos covering will be covered by one thickness of standard 2-ply roofing paper, this paper will be cut in pieces of about 3′ long and wide enough to cover the circumference of the pipe covering, that is, the roll of roofing paper will be cut off in such widths that this width will encircle the circumference of the asbestos covering on the pipe with about a 3″ allowance for lap. The clamps will then be put over the roofing paper. The lap on the roofing paper must be always on the side of the pipe. This paper will also be lapped from section end to section end, allowing about a 2″-lap and covering this lap with a tightly clinched clamp.

Finally the roofing paper will be given two coats of a good quality of black paint.

(36) Receiving House Manifold.—Black merchant pipe and standard black nipples threaded at both ends should be used.

Fittings are to be standard cast iron, flanged, faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Companion flanges are to be standard cast iron companion flanged, faced and drilled to 125 lb. standard dimensions.

Screwed fittings (where necessary) should be medium weight C. I. Crane 175 lb. or equal. (See Section 225).

Valves (for making distillate cuts) are to be standard cross C. I. flanged O. S. & Y. iron body with steel stems and renewable nicaloy seats and fibre discs to withstand gasoline and kerosene reactions (similar to Crane No. 363). The flanges are to be faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Angle valves (for making distillate cuts and used at end of manifold) are to be of same specifications as above O. S. & Y. valves (similar to Crane No. 353).

Sampling valves (in manifold trap) are to be ½″ cocks equal to Crane No. 800.

[1]Look boxes are to be cast iron having 4″ inlets and outlets faced and drilled to A. S. M. E. 125 lb. standard dimensions to be equal in quality to the boxes as manufactured by Joseph Reid Gas Engine Company, as per their latest design drawing No. 2186.

Gaskets are to be $^1/_{16}$″ J. M. Seigelite or equal.

(36-A) Dehydrator (to be of the Vertical Type).—A dehydrator is used to separate the fixed gases and water from the distillates and is always located (between the condensers and the look boxes) within the receiving house. Shell is to be (12″ I. diameter x 5′ 4″ overall) made of 12″ O. D. standard steel pipe. Both ends are to have (¼″ steel) flat heads welded on.

The following (one-half of full length) recessed line pipe couplings are to be welded on the shell in the following locations:

[1] In setting the glass window in look boxes (do not use any rubber gaskets) simply use a litharge paste. If the litharge paste is in the powder form, thin it down with glycerine.

One 2″ coupling; 4″ above bottom (for water draw off adjusting swing pipe).

[1]Two 3″ couplings; 12″ below top (opposite each other) for inlet and outlet of distillates.

One 2″ coupling; in center of top head for gas take-off.

(37) Water Drain from Dehydrator (in Receiving House).—All pipe is to be black merchant pipe.

Nipples are to be standard black nipples threaded at both ends.

Fittings are to be medium weight C. I. screwed ends, equal to Crane 175 lb. (Section 225).

Funnels may be made of C. I. or No. 18 gage galvanized sheet iron with soldered joints.

(38) Gas Line in Receiving House (from Dehydrator and Look Boxes).—Black merchant pipe and standard black nipples threaded at both ends should be used.

Fittings are to be medium weight C. I. screwed ends equal to Crane 175 lb. (Section 225).

Ground joint unions equal to Crane navy should be used.

Screwed-end gate valves, all iron clamp type Crane No. 488 or equal to be packed for oil vapors should be used.

C. I. square head plugs (where necessary) should be used.

(39) Auxiliary Gas Relief at Condenser Coil.—Black merchant pipe and standard black nipples threaded at both ends should be used.

Companion flanges are to be standard C. I. faced and drilled A. S. M. E. 125 lb. standard dimensions.

Screwed-end gate valves I. B. I. M. equal to Crane No. 488 are to be used.

Gaskets are to be $^1/_{16}$″ J. M. Service ring-type or equal.

(40) Steam Line to Fuel Oil Burners (For Oil Atomization).—Are to be similar to either Section 59 or Section 60, depending upon the steam working pressure.

[1] The distillate inlet only must be baffled, by providing a 3″ black nipple and 3″ standard malleable iron tee screwed on, extending to the center axis of shell. The top outlet of tee is left open, while a 3″ black nipple 18″ long is screwed in bottom outlet of tee, (to discharge the distillates towards bottom of dehydrator).

(41) Fuel Gas Lines (in Front of Stills) at Still Burners.—Pipe is to be standard black merchant having welded outlets (specify size) for burner connections. All other pipe is to be black merchant.

Valves (for main gas cut-off) are to be standard flange I. B. B. M. faced and drilled to A. S. M. E. 125 lb. standard dimensions, Crane No. 461 or equal.

Individual cut-off valves to each burner are to be screwed gate valves, iron body, brass mounted (packed for gas) Crane No. 490 or equal.

Needle valves at gas burner are to be screwed needle valves, bronze rough body, finished trimmings, bronze stem ($^7/_{16}''$ diameter seat opening) are to be equal in quality to Lunkenheimer Fig. 906 (packed for gas).

Valves at gage are to be standard brass globe valves equal to Crane No. 1.

Fittings are to be medium weight, cast iron screwed-end equal to Crane 175 lb.

Flanged fittings and companion flanges (if necessary) are to be standard C. I. faced and drilled A. S. M. E. 125 lb. standard dimensions.

Ashton[1] Improved single air brake gage, Case No. 51 B with 5″ dial, and to register 0 to 15 lb. pressures (to be graduated in ½ lb. registrations) is to be used.

Syphons are only necessary when there is water present in the gas then fill the syphon with an anti-freezing solution.

Unions from ¼″ to 2″ should be forged steel (brass to iron seats) threaded connection as manufactured by Walworth Company. Above 2″ use Dart[2] flanged unions.

Gaskets are to be $^1/_{16}''$ J. M. Seigelite or equal.

Gas regulators, as manufactured by the Fulton Regulator Company or equal should be used.

(41-A) The Gas Absorption System.—In fractionating petroleum oils considerable gas is produced, the major portion of this

[1] Ashton Valve Company.
[2] Dart Manufacturing Company.

gas is generated by what is known as the pressure or cracking stills.

The amount varies with the following conditions; *viz.*, characteristics of crude petroleum, the temperature in the still, the size of condenser and the atmospheric temperature.

This gas may be used as a refinery fuel, for gas engines, or gas burners, etc., although some refining plants recover gasoline from the excess gas by means of an absorption system. The absorption system is a process of forcing the gas (with the aid of an exhauster) through an absorbent oil, which absorbs condensable vapors from the fixed gases. This absorbent oil is then pumped into a steam still from which the gasoline content is stripped and the absorbent oil is then used over and over again. Inasmuch as there are two general classes of absorption plants; namely, the plant using horizontal absorbers or the one using the vertical absorbers, a brief description of each will not go amiss. In the horizontal absorption system, a series of large size steel tubes equipped with gage glasses and oil traps are coupled as a unit and each large tube is provided with a perforated pipe coil within ($^1/_{16}''$ ϕ perforations). These large tubes are half filled with the absorbent oil and always maintained at a constant level, the gas forced into the perforated pipe coil percolates through the body of absorbent oil and intimately mixes with it. Here is where the absorption of condensable vapor occurs.

The absorbent oil admixed with these condensable vapors is trapped off and finally fractionated by steam in a steam still with the usual refinery steam still equipment. The vertical tower absorption system consists of a series of vertically installed steel tubes about 36″ ϕ and minimum height thirty-five feet. The gas enters the bottom of towers and is discharged at the top, while the absorbent oil enters the top of the towers and forms a spray caused by interceding baffle plates or the filling of crushed 2½″ x 5″ limestone, trickles gradually to the bottom of the towers where it is trapped off by an oil trap (each tower is equipped with gage glass and oil trap) and finally pumped into a steam still similar to the one described for the horizontal absorbers above.

The receiver house and its equipment such as look boxes, pipe manifold, etc., are practically the same as used for refining straight run gasoline or kerosene and are to be constructed in accordance with Section 120.

The steam still is identical to the one used in usual refinery practice for steam stilling straight run gasoline or kerosene and it consists of a horizontal cylindrical steel tank (see Section 111) having a dephlegmator or scrubbing tower (see Section 114) rigidly anchored on top of still (see Fig. 2). The still is supported by steel, masonry or concrete settings (see Section 112). The entire still is to be covered with an insulation composed of 2½″ asbestos blocks and asbestos cement as per Section 113. The steam pipe coils within still are usually made of 1½″ or 2″ black merchant pipe with standard banded screwed malleable iron fittings (see Section 129). (Materials for pipe coils usually depend upon the steam pressure used). For pressures above 125 lb., use X-Hy, malleable iron fittings. It is well to provide an independent coil for low and high pressure steam.[1] The perforations in the pipe are usually from ⅛″ to $^3/_{16}$″ holes spaced on 1″ centers and staggered for the purpose of uniformly admitting the steam into the body of oil within the still.

The condenser (coil) may be composed of several worms connected in parallel and made of cast iron pipe and fittings. This condenser (coil) may be made similar to Section 118. The steel compartment housing this coil and through which the cold water circulates continuously may be constructed in accordance with Section 118.

Oil traps are to be provided on each absorber, to continually draw off the saturated oil from the bottom of the vertical absorbers and maintain a constant level in horizontal absorbers without allowing the gas to escape. The traps may either be of the float or bucket type and must be designed for the pressure under which they must operate. Traps suitable for this service is made by the Strong, Carlisle and Hammond Company.

The capacity of the absorbent oil pump is dependent upon the rate of oil circulation.

[1] To determine the actual number of perforations see Section 49.

It is recommended to use outside packed plunger pumps for high pressure work and packed piston type for low pressure work.

Oil end is to have C. I. cylinders lined with brass tubes forced into the cylinders. All valves, seats, stems and springs are to be of brass, piston rods of steel. Steam end is to be standard duplex design (state steam working pressure desired). All gaskets on oil end are suitable for oil service. It is advisable to duplicate the pumps in order to avoid shutdowns, and to purchase oversized units in order to secure a longer life.

The oil cooler (if it is used in place of a heat exchanger) is to be made of 2″ standard merchant pipe and connected to 2″ medium weight screwed cast iron return bends to produce a continuous coil through which the absorbent oil enters the bottom (of the coil) and leaves at the top. The uppermost tier of pipes support a galvanized iron trough which evenly distributes (by overflowing) the cooling water throughout the exterior surface of the entire coil.

Specifications for Absorbent Oils.

	Oil #1.	Oil #2.	Oil #3.
Bé. gravity	40.7	35.6	36.9
I. B. P.	500° F.	536° F.	523° F.
F. B. P.	666° F.	698° F.	680° F.
Fire-test	312.8° F.	312.8° F.	318° F.
Saybolt viscosity	40 @ 100° F.	49.5 @ 100° F.	48 @ 100° F.

Capacities for Vertical Absorbers.

$$Q = 314.16 \times d^2 \times \sqrt{\frac{P}{G}}$$

$$d = .526 \times \sqrt{Q \times \sqrt{\frac{G}{P}}}$$

In which :—

P = Absolute gas pressure (Gauge plus 14.7).
G = Specific gravity of gas.
Q = Capacity cubic feet of free gas per 24 hours.
d = Diameter of absorber in inches.

CAPACITIES FOR HORIZONTAL ABSORBERS.

$Q = L \times d \times P \times 1.43.$

In which:—

L = Length of absorber in inches.
d = Diameter of absorber in inches.
P = Absolute gas pressure (Gauge plus 14.7).
Q = Capacity cubic feet of free gas per 24 hours.

(42) Thermometers for Stills (Fullers' Earth Filter and Clay Regenerative Kiln).—Still thermometers are to have separable socket connection and are to be of the angle type.

Scales are to be of brass, black oxidized (9″ high) with range of temperature (specify temperature range) numbers and graduations must be cut in the scale and filled with a permanent white pigment.

Scale cases are to be V-shaped cast of high grade bronze, ground, polished and to have a heavy glass front protection.

For quick registration up to 500° F. specify mercury conducting bath, above 500° F. specify metallic powder. All steel parts of the thermometer are to be heavily copper plated to prevent corrosion. The socket connection which screws into the still should have standard tapered pipe threads.

A temperature recording thermometer should be provided on all oil lines entering fullers' earth filter, design to be as specified above.

A temperature recording thermometer should be provided on the clay regenerative kiln, design is to be as specified above.

(43) Run-Down Lines from Receiving House to Tanks.—Black merchant pipe and standard black nipples threaded at both ends should be used.

The nipples entering tank must be extra heavy.

Fittings are to be "Crane Oil" malleable iron or equal.

Valves are to be flange gate valves, iron body Crane No. 461 or equal packed for oil.

Gaskets are to be $^1/_{16}$″ J. M. Seigelite ring-type or equal.

(44) Pumping Out Lines from Run-Down Tanks.—Pipe is to be black merchant and standard black nipples threaded at both ends.

The nipples into the tank are to be "Lucas" electric welded one-piece flanged nipple-faced and drilled A. S. M. E. 250 lb. standard dimensions.

Fittings are to be medium weight cast iron Crane 175 lb. or equal.

Valves are to be medium-flanged ferro-steel body faced and drilled A. S. M. E. 250 lb. standard dimensions packed for oil and equal to Crane No. 505.

Gaskets are to be $^1/_{16}''$ thick, J. M. Seigelite or equal.

(45) Gas Line from Run-Down Tanks.—Black merchant pipe should be used.

Black nipples with standard threads at both ends should be used.

Fittings should be standard screwed cast iron.

Union ground joint equal to Crane navy unions 98 E should be used.

(46) Drains from Bottom of Run-Down Tanks.—Extra heavy nipples from tank to drain valve should be used.

Extra heavy malleable iron screwed elbow should be used under tank.

Valves (for draining tank) are to be medium screwed end gate valves equal to Crane No. 500.

Pipe beyond drain valve buried in the ground is to be vitrified salt glazed standard No. 1, first quality sewer pipe with the necessary fittings. Pipe is to be laid as specified in Section 57.

(47) Safety Steam Lines (Where Steam Pressure Does Not Exceed 150 Lbs.) from Live Steam Header to Run-Down Tanks.—Main blocks and bleed valves at header main are to be iron body, brass mounted, screwed-end globe valves equal to Crane No. 350½.

Fittings for dead lines from blocks to tanks are to be medium weight screwed C. I. fittings.

(Each block enters tank at extreme top, provide at this point a 12″ loop seal formed of standard pipe). (See Section 79).

All pipe is to be standard black merchant, use all standard black pipe nipples with standard threads at both ends.

Trap on main header (no traps on leads to tanks) is to be H. P. Strong trap or equal.

(For method to determine the size of safety steam lines, see Section 79).

(48) Cooling Box Coils.—Coils are to be made of standard steel pipe with standard steel flanges attached. (For method of determining the necessary square feet of cooling surface see Section 207).

Flanges are to be faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Fittings and return bends (composing coil) are to be standard cast steel faced and drilled A. S. M. E. 125 lb. standard dimensions.

Gaskets are to be $^1/_{16}''$ J. M. Service ring-type or equal.

Pipe is to be supported by suitable supports within cooling box.

(49) Perforated Steam Spray Coil Within Still.[1]—Fittings are to be standard banded, screwed, malleable iron.

Black merchant pipe should be used.

Unions are to be Crane navy 98 E or equal.

Closed coils are to be of same construction as perforated coils.

(50) Heating Coil Within Tanks Where Steam Pressure Does Not Exceed 150 Lbs. (to Reduce Consistency of Oil).—Steel line pipe is to be used.

Fittings are to be malleable iron or medium weight cast iron Crane 175 lb. (See Section 225).

Return bends are to be malleable iron or medium weight cast iron Crane No. 175 (open pattern).

Unions are to be ground joint screwed Crane navy No. 98 E or equal.

Screwed-end, iron body globe valves Crane No. 350½ or equal are to be used.

Traps are to be (specify size and pressure) Sarco[2] steam traps.

[1] The total areas of all perforations are usually calculated as 80 per cent of the pipe area from which the coil is made. (See Section 41-A.)

[2] Sarco Company, Inc.

(51) Caustic Pipe Lines.—Standard black merchant pipe should be used.

Standard black nipples with standard pipe threads at both ends should be used.

Valves should be iron body, iron mounted, screwed-end gate valves Crane No. 488 or equal.

Fittings should be medium weight, cast iron, screwed ends Crane 175 lb. or equal.

Standard black female malleable iron unions should be used.

(52) Acid Lines.—Standard black merchant pipe should be used.

Standard black nipples with standard threads at both ends should be used.

All iron clamp type gate valves Crane 488 or equal should be used.

Fittings should be medium weight, cast iron screwed-ends Crane 175 lb. or equal.

Unions should be malleable iron Crane navy No. 98 E.

(53) Distillate Lines Continuous Light Oil Treating Plant.—Standard black merchant pipe should be used.

Valves should be flanged, rising stem Crane 465 or equal, faced and drilled to A. S. M. E. 125 lb. standard.

Fittings (flanged where necessary) should be standard C. I. faced and drilled A. S. M. E. 125 lb. standard, otherwise use medium weight cast iron screwed-ends Crane 175 lb.

Gaskets should be $^1/_{16}''$ J. M. Service ring-type or equal.

(54) Pump Manifold Transfer and Loading System.—(For pump specifications see Section 73-A).

Valves should be standard flanged gate valves I. B. steel stems O. S. & Y. packed for oil equal to Crane No. 465, faced and drilled to A. S. M. E. 125 lb. standard.

Fittings should be standard flanged C. I. faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Companion flanges should be standard C. I. faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Standard black merchant pipe should be used.

Gaskets should be $^1/_{16}''$ J. M. Seigelite ring-type or equal.

(54-A) Flow of Various Oils in the Proper Lines (For Transfer and Loading System.—In designing or estimating it is necessary to know the various oils that may be pumped through the same pipe line intermittently without destroying original properties of the oils.

12 Deg. crude oil 20 Deg. crude oil 22 Deg. crude oil	May use the same pipe line for the three products.
Naphtha Gas naphtha Heavy naphtha	May use the same pipe line for the three products.

Refined oil—use independent pipe line.
Finished gasoline—use independent pipe line.
Water white (kerosene)—use independent pipe line.
Gas oil—use independent pipe line.
Rerun distillate—use independent pipe line.
Slop lines—use independent pipe line.

(55) Cold Circulating Water System.—Valves from 3″ to 8″ should be standard flanged gate valves, I. B. brass trimmings, non-rising stem, faced and drilled to A. S. M. E. 125 lb. standard dimensions, packed for water and similar to Crane No. 461 or equal.

Valves below 3″ should be standard gate valves I. B. brass trimmings equal to Crane No. 460.

Fittings and flanges above 8″ should be standard flanged, cast iron faced and drilled to A. S. M. E. 125 lb. standard.

Screwed fittings below 8″ should be medium weight cast iron, screwed Crane 175 lb. or equal.

Pipe should be black merchant and standard black nipples should be used.

Gaskets should be Garlock special duck insertion sheet packing for flanged connections (order in square feet and cut in the field to suit pipe).

(56) Main Circulating Water Pump-House.—Same specifications should be used as in cold circulating water system. (Section 55).

(57) Cooling Water System for Returning Water to Reservoir.—Pipe should be standard No. 1 quality vitrified salt glazed pipe.

Fittings should be standard No. 1 quality vitrified salt glazed sewer pipe fittings (to suit above pipe).

Pipe should be laid as follows and buried below frost line.

First spun dry oakum is inserted around joint to fill one-half of hub space, then a 1:2 mixture of Portland cement and sharp clean sand seal, is used to completely fill the balance of space between pipe and the socket of the hub. The inside of pipe must be swabbed out in order to remove any cement that perchance may have been forced through the joint.

(58) Distilling Plant Tail and Run-Down Gas Receiver Specification.—Fulton[1] duplex sensitive vacuum regulators or equal should be used.

Black merchant pipe should be used.

Standard black nipples should be used with standard threads at both ends.

Valves at regulator by-pass above 2½″ should be standard flanged gate valves I. B. B. M. non-rising stem Crane No. 461 or equal faced and drilled A. S. M. E. 125 lb. standard dimensions. Valves under 2½″ should be Crane No. 490 or equal.

Flange fittings and companion flanges should be standard flanged C. I. faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Screw fittings should be medium weight C. I. similar to Crane 175 lb. or equal.

Unions should be Crane navy No. 98 E or equal.

Gaskets should be $^1/_{16}$″ J. M. Seigelite ring-type or equal.

(59) Specifications for Low Pressure Steam Lines (For Pressures from 16 to 100 Lbs.).—Temperatures range from 216 to 327° F. respectively.

Gate valves above 2″ O. S. & Y. are to have C. I. body bonnet and disc. Brass mounted and steel stem valves should be designed so that they may be packed while under pressure when open. Under 2″ use a non-rising stem equal to Crane No. 438.

[1] The Chaplin-Fulton Manufacturing Company.

Globe valves above 2″ are to have C. I. body with yoke. Brass mounted and steel stems, under 2″ are to be of the regrinding type equal to Crane No. 70.

When necessary the main header should be provided with a standard C. I. flanged drip pockets of proper size.

Separators (when necessary) are to be installed as close as possible to points of use. They should be made entirely of cast iron and equipped with water gage glass, and the flanges to be faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Traps should be a standard pressure Strong trap or equal.

Fittings below 2½″ are to be standard weight screwed end cast iron or standard malleable iron. Fittings 2½″ and above are to be standard flanged C. I. faced and drilled to A. S. M. E. 125 lb. standard.

Pipe under 4″ should be standard merchant, above 4″ and up to 12″ should be full weight steel pipe, above 12″ it should be O. D. sizes, and (thickness is dependent upon diameter) lap-welded steel pipe.

Gaskets are to be $^1/_{16}$″ J. M. Service ring-type or equal.

Expansion joint is to be standard flanged C. I. body, brass sleeve, expansion joint is to be packed for steam (state pressure) working pressure and faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Unions 1½″ and under are to be malleable iron, above 1½″ use ground joint brass to iron seat cast iron flanged unions.

Drips and drains are to be according to same specifications as the respective lines they drain.

Pipe over 4″ should be covered with 1½″ thickness of 85 per cent magnesia. Pipe under 4″ should be covered with standard thickness of 85 per cent magnesia. Fittings, valves and flanges should be covered with block and cement of same material and thickness as their respective leads. Insulation should be covered with an 8-ounce canvas (sewed on) jacket over rozin-sized paper. It should be painted with two coats of lead and oil over one coat of glue sizing.

Pipe supports may be made of wrot-iron or steel and should be spaced on 10 to 12 feet centers (supports for smaller pipes

should be spaced more frequently). The pipes should be properly suspended in order to permit free expansion and contraction. Bracing may be necessary in some cases to eliminate vibrations.

(60) Specifications for High Pressure Superheated Steam Lines.—(For working pressure of 250 lbs. plus 300° F., superheat).

Gate valves above 1¼″ are to be O. S. & Y. X-heavy flanged cast steel body, bonnet and disc, monel seat and disc rings and monel metal stem, faced and drilled to A. S. M. E. 250 lb. standard dimensions.

All valves 6″ and larger should have a by-pass valve of same construction, as main valve, under 1¼″ valves should be screwed-end X-heavy gate valve O. S. & Y. equal to Crane No. 68 E.

Globe valves 2″ to 10″ inc., are to be X-heavy flanged cast steel body, bonnet, and disc and monel metal stem, seat and disc rings, faced and drilled A. S. M. E. 250 lb. standard dimensions.

Two-inch and smaller are to be screwed-end X-heavy globe valves equal to Crane No. 228 H.

Fittings 2½″ and larger are to be X-heavy cast steel flanged fittings, conforming to A. S. M. E. 250 lb. standard dimensions.

Fittings under 2½″ are to be X-heavy C. I. screwed ends.

When necessary standard C. S. flanged drip pockets equipped with a water g'ass should be installed.

Separators (when necessary) are to be installed as close as possible to point of use, and should be made entirely of cast steel having a water glass, and the flanges to be faced and drilled to A. S. M. E. 250 lb. standard dimensions.

Traps are to have malleable iron tanks, cast iron inlet supports and valve, bodies, hard metal trunnions and sleeves with monel metal seats, disc and stems. Traps are to be No. 30 Crane tilt non-return or equal. (Always specify the pressure when ordering any traps).

Pipe 2½″ and larger should be lap welded wrot steel.

Two-inch and smaller should be butt welded wrot steel.

All pipe should be full weight except, those as noted otherwise below.

Eight-inch pipe should weigh 28.55 lbs. per lineal foot.

Ten-inch pipe should weigh 40.48 lbs. per lineal foot.

Twelve-inch pipe should weigh 49.56 lbs. per lineal foot.

O. D. pipe weights depend upon the size of the pipe.

Expansion should be taken care of by using expansion bends made of the same size pipe as the main header. The bends must be free from buckles and creases. Flanges should be faced at right angles to the center line of header.

Gaskets should be $^1/_{16}''$ J. M. Service or equal.

Unions 1½″ and smaller, should be Crane No. 98 E or equal, above 1½″ use cast steel flanged unions.

Drips and drains should be according to same specifications as the respective lines they drain.

Pipe 4″ and over should be covered with 3″ thickness (broken joints) of 85 per cent magnesia. Pipe 4″ and under, should be covered with double standard thickness (broken joints) of 85 per cent magnesia.

Fittings, valves and flanges, block and cement insulation should be of same thickness and material as their respective leads.

All sections should be applied without canvas jackets, joints sealed with asbestos cement.

Pipe supports should be similar to specifications for low pressure steam lines under Section 59.

(61) Exhaust Steam Piping.—Gate valves 2″ up to 12″ should be O. S. & Y., having C. I. body bonnet and disc and brass seat and disc rings. Valves should be designed so they may be packed under pressure, faced and drilled A. S. M. E. 125 lb. standard dimensions. Small valves are to be all brass.

Back pressure valves (state type, vertical or horizontal) should be equipped with a water seal and cushioning device. Valves should be set for a pressure of 5 lbs. and are to be iron body, brass mounted, faced and drilled to A. S. M. E. 125 lb. standard.

Flanges and fittings 2½″ and above should be standard flanged C. I. conforming to A. S. M. E. 125 lb. standard, under 2½″ use standard screwed malleable iron or cast iron.

Exhaust pipe head should be galvanized sheet metal flanged as per Crane page 543, faced and drilled A. S. M. E. 125 lb. standard dimensions.

Traps should be L. P. Strong traps or their equal.

Black merchant pipe should be used.

Gaskets should be $^1/_{16}''$ J. M. Service ring-type or equal.

Unions $1\frac{1}{2}''$ and smaller should be ground joint and made of brass, above $1\frac{1}{2}''$ use standard flanged C. I. union.

Discretion should be exercised whether or not the service demands any insulation.

Pipe supports are similar to specifications for low pressure steam lines under Section 59.

(62) Boiler Feed Piping (for Pressures from 200 to 300 Lbs. W. P.)—Companion flange and fittings $2\frac{1}{2}''$ and above are to be ferro-steel flanged fittings, conforming to A. S. M. E. 250 lb. standard dimensions. Fittings under $2\frac{1}{2}''$ are to be X-heavy malleable iron or cast iron with screwed ends.

Pipe $2\frac{1}{2}''$ and above is to be X-heavy lap welded pipe.

Pipe under $2\frac{1}{2}''$ is to be X-heavy butt welded.

Where conditions demand it, use X-heavy drawn brass pipe (iron pipe sizes).

Bends are to be made of X-heavy wrot steel pipe and must be free from buckles.

Gaskets are to be $^1/_{16}''$ cranite or its equal.

Gate valves $1\frac{1}{4}''$ and above are to be O. S. & Y. to have ferro-steel body bonnet and disc with hard metal seats and disc rings.

Valves are to have rolled bronze stems. Valves designed so as to be packed under pressure, equal to Crane No. 7 E. Valves above $6''$ are to have a by-pass valve similar in construction to main valve.

Swing check valves $2''$ and above are to have ferro-steel body, bonnet and disc, and are to have hard metal seats and disc rings.

(63) Boiler Blow-Off Lines.—The pipe and bends are to be full weight lap welded steel pipe similar in specifications for steam lines.

Blow-off lines are to have one heavy asbestos packed cock and one valve of the Y-type ferro-steel body and bonnet, C. I. seat

and disc and manganese bronze stem, similar to Crane No. 393½ or equal.

Fittings are to be flanged ferro-steel and should conform to A. S. M. E. 250 lb. standard dimensions.

Gaskets are to be 1/16″ Garlock or equal.

(64) Air Compressor Air Piping (All Fitting Used on Air Lines Should be Ordered "For Air Lines").—Fittings should be standard weight C. I. with screwed ends. (All elbows are to be long radius pattern). A special graphite paint should be used on all joints.

Pipe is to be standard black merchant.

Unions under 2½″ are to be standard weight brass with ground joints.

Unions above 2½″ are to be standard weight C. I. flanged unions.

Brass disc and seat valves will not remain permanently tight on air lines, use valves only purposely designed for air service with soft discs equal to Pratt & Cady.

All air suction or discharge pipe should be free from all roughness, scale or foreign substance and must be thoroughly cleansed of dirt, etc., before being erected.

(65) Fuel Oil Piping.—To compute the required amount of fuel oil for boilers see Section 237).

Oil heater shell is to be wrot steel and welded to C. I. flanges.

Heads are to be C. I. Tube sheets are to be rolled steel. Tubes (state size and thickness wanted) are to be seamless drawn steel.

Heater is to withstand a working pressure of 250 lbs. per square inch.

Pumps are to be equipped with an all-bronze Mason No. 160 piston-type steam fuel oil pump pressure regulator. An approved temperature thermometer should be provided in the oil line. 20° Bé oil is to be heated to 200° F.; 16° Bé oil is to be heated to 250° F., and 12° Bé oil is to be heated to 300° F.

Fittings are to be screwed-end medium weight C. I.; for pressures above 175 lbs. use X-Hy fittings.

Pipe is to be standard black merchant; for pressures above 125 lbs. use X-Hy pipe.

Unions are to be malleable iron equal to Crane 98 E.

Plugs are to be standard C. I. square head plugs.

Bushings are to be C. I. shoulder bushings.

Minimum size of suction advisable is 3″ in diameter. A suitable relief valve and strainer should be provided, and any dead ends in the discharge header should be avoided.

Valves are to be screwed-end, clamp brass mounted gate valves equal to Crane No. 490.

Covering of fuel oil line is to be 1″ thick 85 per cent magnesia sectional pipe insulation and necessary 8-ounce canvas, rosin-sized paper, and sewing twine.

(66) Specifications for Pump Fluid Ends.—The proper composition for the fluid ends of pumps.

It is recommended that the fluid ends of pumps, for pumping various materials should be as follows:

Material to be pumped	Fluid end of pump
Ammonia	Cast iron.
Brine	Brass fitted or other composition
Caustic soda	Cast iron.
Hydrochloric acid	Lead lined.
Hot water	Brass or cast iron.
Asphaltic base residue (Tar)	Cast iron.
Weak sulphuric acid	Lead lined, or bronze.
Strong sulphuric acid	Cast iron.
Salt water	Brass fitted or other composition
Petroleum	Brass fitted.

(67) Specifications for Fuel Oil Pumps.—(Specify size as 6″ x 4″ x 6″) Horizontal, duplex, double-acting piston-pattern steam pump. Steam end is to be standard duplex design and designed for a W. P. of 150 lbs. per square inch.

Fuel oil end working pressure is to be 200 lbs. per square inch and is to be fitted to handle oil at a maximum tempera-

ture of 250° F. Oil end is to be C. I. cylinders with brass tubes forced in. All valves, seats, stems, and springs are to be of brass. Piston rods of bronze, pump piston of C. I. with white metal packing rings. All gaskets on oil end are suitable for hot oil.

(68) Specifications for Distillate Pumps.—(Specify size as required 12″ x 6″ x 12″) Horizontal, duplex, double-acting piston-pattern steam pump. Steam end W. P. is to be 150 lbs. per square inch, steam end to be standard duplex design. Oil end W. P. is to be 150 lbs. per square inch. Fluid end should be oil fitted.

Oil end is to be C. I. cylinders, lined with brass tubes forced into cylinders. All valves, seats, stems and springs are to be of brass. Piston rods are to be of steel. Pump piston C. I. with C. I. piston rings. All gaskets on oil end are suitable for cold distillates such as naphtha, benzine, gasoline and kerosene.

(69) Specifications for Caustic Solution Pumps.—(Specify size as 4″ x 3″ x 4″—as required) Horizontal, double-acting piston-pattern steam pumps. Steam end is to be standard duplex design. Fluid end W. P. is to be 200 lbs. per square inch. Fluid end is to be all iron end as it must handle a caustic solution.

(70) Specifications for Diluted Sulphuric Acid Pumps.—(Specify size as 4″ x 3″ x 4″—as required) Horizontal, duplex, double-acting piston-pattern steam pump. Steam end W. P. is to be 150 lbs. per square inch. Steam end is to be standard duplex design. Fluid end W. P. is to be 200 lbs. per square inch. Fluid end is to be all bronze end, as it must handle diluted sulphuric acid.

(71) Specifications for Hot Water Pumps.—(Specify size as 12″ x 6″ x 12″—as required) Horizontal, double-acting piston-pattern steam pumps. Steam end W. P. is to be 150 lbs. per square inch. Steam end is to be standard duplex design. Water end W. P. is to be 150 lbs. per square inch. Fluid end is water fitted and made of C. I.; the cylinders should be lined with brass sleeves forced in. All valves, seats, stems and springs are to be

made of brass. Piston rods are to be of steel, pump piston cast iron with fibrous packing for hot water (specify temperature).

(72) Specifications for Pumps' Charging and Pumping Out Stills.—Specify size as 12″ x 6″ x 12″—as required) Horizontal, duplex, double-acting piston-pattern, steam pumps. Steam end is to be standard duplex design for a working pressure (state pressure per square inch). Oil end is fitted to handle oil at a maximum temperature of 300° F. and having a W. P. (state pressure per square inch). Oil end is to be C. I. cylinders lined with brass tubes forced in. All valves, seats, stems and springs are to be of brass. Piston rods of steel, pump piston C. I. with C. I. piston rings. All gaskets on oil end are to be suitable for hot oil. Pumps are to be packed for oil.

(73) Specifications for Circulating Water Pumps (for Entire Refinery Use).—It is recommended to use motor driven centrifugal pumps. The pumps and motor are to be fixed on one common base and connected with a flexible coupling. Pump is to be horizontal split-casing, double-suction, bronze impeller, brass covered shaft, and should discharge (specify the number of G. P. M.) against (specify head in feet) the desired head and whatever line pressure there may be. Pump is to handle clear water. Suction ranges from 4′ flooded suction to 4-foot lift. The suitable motor to drive these pumps may be purchased from the General Electric Company.

(73-A) Specifications for Transfer and Loading Pumps.—The pumps may be either reciprocating or rotary pumps, hence these specifications will cover both types.

Reciprocating Pumps.—(Specify size as 12″ x 8″ x 12″) Horizontal, duplex, double-acting piston-pattern steam pumps. Steam end W. P. pressure is to be 150 lbs. per square inch and is to be standard duplex design. Fluid end W. P. is to be 150 lbs. per square inch and is to be oil fitted. Its cast iron cylinders should be lined with brass tubes forced in. All valves, seats, stems and springs are to be of brass. Piston rods should be of steel. Pump piston should be of cast iron with cast iron snap rings. All

gaskets on oil end are suitable for oil service. The pump must be packed for oil.

Rotary Pumps.—The pump is to be of the high lift type (specify head in feet) having a displacement of (specify gallons per minute desired). The pump is to be guaranteed to deliver (specify g. p. m.) light petroleum distillates against (specify in feet) the head desired. Pump is to be motor gear driven, the gear to be semi-steel and enclosed in oil tight housings, adjustable self-oiling bearings, and improved lantern ring stuffing boxes. The motor is to be a squirrel cage induction motor (specify H. P.; voltage, and R. P. M.) complete with hand starting compensator having overload and low voltage coils, disconnecting switch, and provided with a rawhide pinion, brass shrouded.

Type of Motors for Rotary or Centrifugal Pump Service.—To determine size of motors for centrifugal pumps see Section 206-A).

Squirrel cage motors may be employed up to 500 H. P. (when the line disturbance is not objectionable caused by the starting full load pumping torque).

Synchronous motors are not usually employed below 75 H. P. and are for constant speed duty only. (They must be relieved of their load in starting until they pull into step.)

Wound-rotor motors for a-c. current and compound wound motors for d-c. current are the best for the service as they possess strong starting characteristics and thereby start with less line disturbance.

Brush shifting commutator a-c. current motors are equally as good as wound-rotor or compound motors where adjustible speed operation is wanted.

(74) Lubricators for Steam Pumps Should Be as Follows.—Finished bronze lubricators, double connection (state capacity in pints) with sight feed and indicator glasses, similar to Lunkenheimer[1] "Senior" Lubricator. (As an alternate use Lunkenheimer "Marvel" mechanical lubricator Type-912).

[1] Lunkenheimer Company.

Duplex Piston Pumps
(General Service Type) (Bronze Tube Liners) for 200 Lb. W. P.
(National Transit Co.)

Diam. steam cyls., inches	Diam. fluid cyls., inches	Length stroke, inches	Max. strokes each side per min.	Piston speed, ft. per min.	Gals. per stroke	Gals. per min.	Barrels per hr. (42 gal.)	Pipe sizes: Steam, inches	Pipe sizes: Exhaust, inches	Pipe sizes: Suction, inches	Pipe sizes: Discharge, inches	Floor space: Length	Floor space: Width
3	2	3	160	40	0.04	13	17	3/8	1/2	1 1/4	1	2′2″	9″
3 1/2	2 1/4	4	150	50	0.06	21	30	3/8	1/2	1 1/2	1 1/4	2′5″	9″
4 1/2	2 3/4	4	150	50	0.10	30	42	1/2	3/4	2	1 1/2	2′9″	1′1″
5 1/4	3 1/2	5	140	58	0.20	56	80	3/4	1	2 1/2	1 1/2	3′1″	1′3″
6	4	6	130	65	0.33	84	120	1	1 1/4	3	2	3′6″	1′5″
7 1/2	5	6	130	65	0.51	132	188	1 1/4	1 1/2	4	3	3′11″	1′9″
7 1/2	4 1/2	10	108	90	0.69	150	210	1 1/4	1 1/2	4	3	5′0″	1′9″
7 1/2	5 1/4	10	108	90	0.93	203	290	1 1/4	1 1/2	4	3	5′1″	1′9″
9	5 1/4	10	108	90	0.93	203	290	1 1/2	2	4	3	5′2″	1′11″
10	6	10	108	90	1.22	264	370	1 1/2	2	5	4	5′2″	2′0″
10	6	12	100	100	1.47	290	410	1 1/2	2	5	4	5′6″	2′0″

Duplex Piston Pumps
(Turret Top Type) for 100 Lb. W. P.
(National Transit Co.)

Diam. steam cyls., inches	Diam. fluid cyls., inches	Length stroke, inches	Max. strokes each side per min.	Piston speed, ft. per min.	Gals. per stroke	Gals. per min.	Bbls. per hr. (42 gal.)	Pipe sizes: Steam, inches	Pipe sizes: Exhaust, inches	Pipe sizes: Suction, inches	Pipe sizes: Discharge, inches	Floor space: Length	Floor space: Width
8	6	12	100	100	1.47	290	410	1½	2	8	6	7′2″	2′5″
8	7	12	100	100	2.00	400	570	1½	2	8	6	7′2″	2′5″
8	8	12	100	100	2.61	520	740	1½	2	8	6	7′2″	2′5″
8	9	12	100	100	3.30	660	940	1½	2	8	6	7′2″	2′5″
10	6	12	100	100	1.47	290	410	2	3	8	6	7′2″	2′5″
10	7	12	100	100	2.00	400	570	2	3	8	6	7′2″	2′5″
10	8	12	100	100	2.61	520	740	2	3	8	6	7′2″	2′5″
10	9	12	100	100	3.30	660	940	2	3	8	6	7′2″	2′5″

Duplex Piston Pumps

(Eagle Works Type) Bronze and C. I. Removable Liners.

(National Transit Co.)

								Pipe sizes				Floor space		
Diam. steam cyls., inches	Diam. fluid cyls., inches	Length stroke, inches	Max. strokes each side per min.	Piston speed, ft. per min.	Gals. per stroke	Gals. per min.	Barrels per hr. (42 Gal.)	Steam, inches	Exhaust, inches	Suction, inches	Discharge, inches	Length	Width	Working pressure
6	3	6	130	65	0.18	48	68	1	1¼	3	2	3′6″	1′5″	200
6	4	6	130	65	0.33	84	120	1	1¼	3	2	3′6″	1′5″	200
7½	4	10	108	90	0.54	116	168	1¼	1½	4	3	5′1″	1′10″	200
7½	4½	10	108	90	0.68	148	210	1¼	1½	4	3	5′1″	1′10″	200
7½	5	10	108	90	0.85	184	265	1¼	1½	4	3	5′1″	1′10″	200
7½	5¼	10	108	90	0.93	203	290	1¼	1½	4	3	5′1″	1′10″	200
7½	6	10	108	90	1.22	264	375	1¼	1½	5	4	5′2″	1′11″	125
7½	6½	10	108	90	1.43	310	440	1¼	1½	5	4	5′2″	1′11″	125
7½	7	10	108	90	1.66	360	510	1¼	1½	5	4	5′2″	1′11″	125
9	5	10	108	90	0.85	184	265	1½	2	4	3	5′1″	1′11″	200
9	5¼	10	108	90	0.93	203	290	1½	2	4	3	5′1″	1′11″	200
9	6	10	108	90	1.22	264	375	1½	2	5	4	5′2″	1′11″	125
9	7	10	108	90	1.66	360	510	1½	2	5	4	5′2″	1′11″	125
10	6	10	108	90	1.22	264	375	1½	2	5	4	5′3″	2′1″	200
10	6½	10	108	90	1.43	310	440	1½	2	5	4	5′3″	2′1″	200
10	7	10	108	90	1.66	360	510	1½	2	5	4	5′3″	2′1″	200
10	6	12	100	100	1.46	290	415	1½	2	5	4	5′8″	2′1″	200
10	7	12	100	100	1.99	400	570	1½	2	5	4	5′8″	2′1″	200

Duplex Piston "Foam" Pumps
(Atlantic Type)
(National Transit Co.)

Diam. steam cyls., inches	Diam. fluid cyls., inches	Length stroke, inches	Max. strokes each side per min.	Piston speed, ft. per min.	Gals. per min.	Barrels per hr. (42 gal.)	Working pressure	Pipe sizes, inches				Floor space	
								Steam	Exhaust	Suction	Discharge	Length	Width
10	6	12	75	75	220	314	200	2½	3	2-5s	5	8′0″	3′6″
12	8	12	75	75	390	557	200	2½	3	2-6s	6	8′4″	3′10″
14	8	12	75	75	390	557	200	2½	3	2-6s	6	8′4″	3′10″
12	8	18	66	100	520	742	200	2½	3	2-6s	6	9′4″	3′10″
16	10	18	66	100	820	1170	200	2½	3	2-7s	7	10′0″	4′6″
18	10	18	66	100	820	1170	200	3	4	2-7s	7	10′0″	4′6″
20	12	18	66	100	1170	1675	200	4	5	2-8s	8	10′3″	4′10″

How to Determine Actual Capacity of Pumps.

It is recommended to operate the pump at 80 per cent of the rated piston speed, also an additional 5 per cent reduction of the gallons per minute due to the slippage of rods.

Example:

The maximum capacity of a 7½" x 6" x 10" pump is 264 G. P. M., running at 90 feet per minute. The proper piston speed of this pump should only be 72 feet.

Solution:

Running the pump at 72 feet per minute	=	20 per cent reduction.
Additional for slippage of rods	=	+5 per cent reduction.
Total	=	25 per cent reduction.

Then:

264 GPM — (264 GPM x 25 per cent) = 198 GPM, correct capacity of pump.

Suggestions on the Installation of Pumps.—Place the pump as near the supply of fluid to be pumped, as possible as the atmospheric pressure alone forces the fluid into the pump and the shorter the suction lift the greater the volumetric efficiency of the pump.

When the fluid to be pumped is hot it should flow to the pump under a head of from five to ten feet.

See that the pump is properly leveled on the foundation and all pipe connections properly made; also see that proper lubrication is provided.

The pipe openings on the pump should be blown out and cleaned properly before making permanent pipe connections.

Pipe sizes used should not be smaller than those specified, and should be increased where the lines are long or contain excessive turns or bends. The suction pipe especially should be amply large in order to maintain as low a velocity as possible.

Be sure that the suction piping is absolutely air tight in order that the pump chambers will properly fill.

See that an ample supply of fluid, free from entrained air or foreign matter is always within the proper suction limit—never exceeding 20 to 25 feet—in better practice 18 feet is not exceeded.

Draining the whole machine is very necessary in freezing weather when it is not in constant use; tapped openings are pro-

vided in both the steam and fluid cylinders—see that proper draining facilities are connected thereto.

A foot valve is always recommended especially with long suction lines or high lifts.

A strainer should be provided when the fluid to be pumped contains foreign matter.

(75) Relief Valves for Pumps.—Valves should be brass cylinder relief valves with male base equal to Crane No. 1134.

(76)[1] Specifications for a 30′ x 10′ Run-Down Tank.—*Dimensions*—Tank is to be 30′ diameter x 10′ high in the shell, with cone roof. (Slope of cone roof to be 1½″ per foot.)

Material—Bottom and shell are to be made of open hearth tank steel plate.

Bottom plates are to be of $^3/_{16}$″ plate weighing 7.65 lbs. per square foot.

First ring of shell to be $^3/_{16}$″ plate weighing 7.65 lbs. per square foot.

Second ring of shell to be $^3/_{16}$″ plate weighing 7.65 lbs. per square foot.

Angles—Bottom angle should be 2½″ x 2½″ x $^5/_{16}$″, top angle 2½″ x 2½″ x ¼″.

Roof—Roof is to be constructed of $^3/_{16}$″ steel plate weighing 7.65 lbs. per square foot built of rectangular plates and have a rise of approximately 2′6″. Roof is to be supported with a central 8″ pipe column with 18–6″ x 8.2 lbs. channel rafters, riveted to crown plate in center and to shell of tank with angle clips.

Man-Heads—One 20″ shell man-head with bolted cover is to be placed in the first ring, and one 20″ diameter roof man-head with bolted cover in roof.

Openings—Tanks are to be furnished with the following pressed steel flanges—three 6″, five 2″ and two 4″. Also one 4″ flange in roof is to be equipped with a 4″ brass plug to facilitate gaging contents of tank.

Swing-Pipe—One 8″ swing pipe complete with double-threaded nipple riveted to double hub flange—complete with swing joint and windlass, cable sheaves, etc.

[1] See pages 184–193.

Stairway—Tank is to be provided with one steel stairway of standard construction.

Painting—Upon completion of the bottom before lowering, it should be given one coat of black carbon paint.

Riveting—Rings one and two are to be riveted with $^7/_{16}''$ diameter rivets $1\frac{1}{2}''$ pitch. Girth seams single riveted, vertical seams single riveted, $^7/_{16}''$ rivets $1\frac{1}{2}''$ pitch.

Caulking—All seams in the bottom are to be caulked in the inside. All seams in shell and roof are to be caulked on the outside.

Testing—Tank is to be tested when full of water. Purchaser is to furnish water and to fill tank without delay or expense to seller when same is ready for the test.

In General—Customer is to furnish and prepare a level grade which shall be not less than 35′ in diameter. Tank is to be riveted in the usual manner, caulked, tested and made tight when full of water.

(77) Fire Dikes (Around Run-Down Tanks or Stills).—Fire dikes may be constructed of earth filling or made of reinforced concrete. If made of concrete, the mixture should be:

One part Portland cement,

Three parts clean, sharp sand,

Five parts crushed limestone to pass $1\frac{1}{2}''$ diameter ring.

After concrete is set, a brush coat of cement plaster should be applied on exposed part of wall.

Reinforcement that is necessary is to be plain or deformed round bars, conforming to latest standard specifications of A. S. T. M.

The soil under base is to be well dampened just before pouring the concrete.

(78) Reinforced Concrete Pipe Trenches.—Trenches are to be constructed in accordance with drawing. (Specify drawing number). Concrete mixture should be $1:2\frac{1}{2}:5$ or

One part Portland cement,

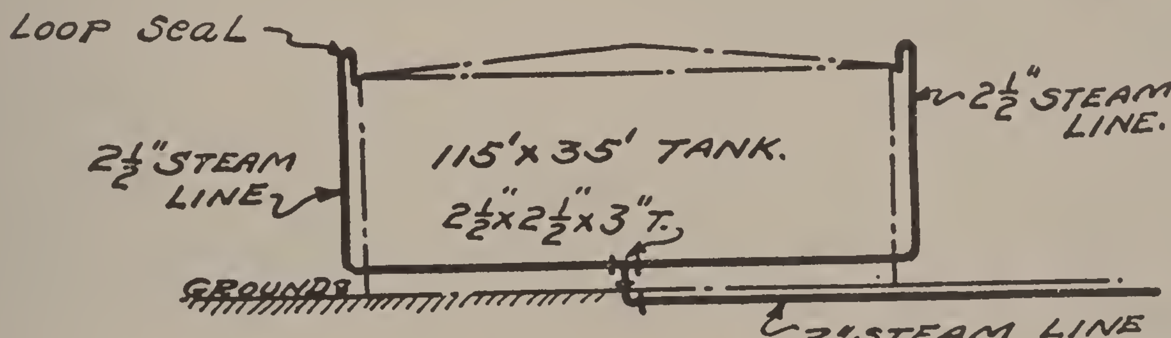
Two and one-half parts clean, dry sand,

Five parts crushed limestone to pass 1½″ diameter ring or clean washed gravel.

The walls and floor of trench should not be less than 6″ thick and the reinforcement that is necessary is to be plain or deformed round bars, conforming to latest standard specifications of A. S. T. M.

The trench should be covered with firm tread plates of proper thickness and should set flush with top of trench walls. Provide C. I. Bell traps for draining the trenches and connect these traps into the sewage system.

(79) **Safety Steam Fire Lines for Oil Storage Tanks.**—It is essential that all oil storage tanks be equipped with steam fire lines for use in case of fire. (See Fig. 8.)



Above figure Illustrates the usual Safety Steam Fire Connections for a 115 Ft. x 35 Ft. Oil Storage Tank.

Fig. 8.

The proper size of steam lines for various size tanks is as follows:

One 2″ steam connection for tanks up to 25 feet diameter.

Two 2″ steam connection for tanks 30 feet to 60 feet diameter.

Two 2½″ steam connection for tanks over 60 feet diameter.

All run-down storage tank steam fire lines must be controlled from the receiving (tail) house.

CRACKING PLANT.

(See Fig. 3).

Because of the frequent and at times violent changes in market conditions and prices, it would seem essential for the refiner to select cracking equipment which is capable of cracking any and every type of crude oil as well as any distillate or residue therefrom. For this reason the author will describe the Dubbs Process which appears to meet these conditions to the fullest extent in commercial operation.

A single-unit Dubbs cracking still has a rated capacity of five hundred barrels of charging stock per twenty-four hours. The units are usually built in pairs, called a double unit, and operated by one crew of three men per shift, from a control or receiver house which contains the pumps and recording temperature instruments serving both units.

The heating element consists of a coil of fifty 4″ seamless drawn steel tubes located in the heated compartment of a side fired furnace (No. 80). The tubes are connected in series by forged steel return bends, having aluminum bronze plugs, which are easily removable at the end of a run for inspection and cleaning of the tubes.

The material to be cracked whether kerosene, gas oil, fuel oil, still bottoms or topped crude, is pumped from the storage tank to the heating coil, either direct to the tubes or overhead through the dephlegmator and then by gravity to the inlet connection into the tubes.

The flow of the oil in the coil is counter current to the travel of the hot gases in the furnace. The oil emerges from the coil, at its cracking temperature, passes through the transfer line (No. 81) and enters the top of the so-called expansion or reaction chamber (No. 82) which is located alongside but several feet distant from the furnace and entirely outside the fire zone.

The reaction chamber (No. 82) is of 10 feet in diameter by 15 feet high. It is of seamless hammer-welded construction. Flanged manway openings are at the top and the bottom. The entire chamber is covered externally with a steel housing, heavily insulated to prevent heat from being lost by radiation.

The oil within the reaction chamber occupies a very small space, usually less than 2 feet in height. In this chamber the reaction or cracking occurs with the consequential separation of the carbon or coke from the liquid oil. The vapors leave the chamber through the vapor line (No. 83). The unvaporized oil is continuously drawn off from, or near the bottom of the chamber and passes through the residuum line (No. 95) to the residuum cooler (No. 98 and coil No. 99) and it is then discharged into the residuum storage tank (No. 100-A). It is impossible for the unvaporized oil, or the residuum, to syphon back to the coil. The chamber serves as the holder for the coke, with a capacity of 25 to 35 tons of coke per run.

Oils vary greatly in their carbon content so that the length of the run depends upon the length of time required to fill the chamber with coke. A very simple and easy method is used to break up the mass of coke so that the time for cleaning is only a few hours.

The coke itself is commercially dry and of excellent quality. A thin layer of carbon is intentionally left upon the inside walls of the chamber to act as additional insulation for retaining heat within the chamber and further, as a protection against corrosion from oils which may contain a large percentage of sulphur.

The unvaporized oil, or residuum, is a commercial fuel oil, having the advantage of zero cold test and low viscosity. The B. t. u. value per gallon is higher than that of straight run fuel oil.

The cracked vapors leaving the chamber through the vapor line (No. 83) pass to the dephlegmator (No. 84) where the heavier portions are separated and drop by gravity down the leg of the dephlegmator (No. 85) and join the raw oil in the feed line (No. 96) and thus recirculate back to the coil for further treatment. The light cracked vapor (pressure distillate vapor) passes from the top of the dephlegmator through the vapor line (No. 87) to a water condenser (No. 88) and then into the pressure distillate receiving tank (No. 89). The tank is adjacent to the control house (No. 92). It is 3 feet in diameter by 6 feet high and may be either carefully riveted or hammer-welded.

From this tank the pressure distillate is sent to storage (No. 90) through a pressure reducing valve without the aid of a pump.

A uniform predetermined pressure of 120 to 150 pounds is maintained throughout the system, through the coil, the reaction chamber, the dephlegmator, the condenser and the distillate receiving tank. The excess pressure produced by the gas generated in the system is released at the outlet side of the receiving tank. The release of this excess gas is regulated by the operator in the control house. Because condensation has taken place under pressure, the gas is comparatively dry. The gas may be delivered to a small scrubber, to remove any gasoline or benzine content, or it may be piped direct to the furnace to be burned as fuel. The amount of gas produced is, alone, not sufficient to supply all the necessary fuel so that a limited amount of oil is required. The cracking action in each passage of the oil through the coil is very mild and the large ultimate yields in each throughput is accomplished by the successive passages of the oil through the coil after it has dropped its carbon in its passage through the reaction chamber and the uncracked vapors are condensed and automatically returned by gravity to the coil for successive cracking.

Part of the pressure distillate from the receiving tank may be pumped back (No. 86) to the top of the dephlegmator to act as a cooling medium to aid in precipitating the heavy vapors for return to the heating coil. The greater part of the pressure distillate so pumped will be vaporized immediately in the dephlegmator and then be recondensed in the pressure distillate condenser. There are several alternative means for cooling and separating the vapors within the dephlegmator, such as feeding part or all, of the raw oil (No. 101 and No. 102) direct to the dephlegmator. This method is frequently used and shows economy in fuel. In many cases, a combination of raw oil and pressure distillate is fed to the top of the dephlegmator.

A very steady and uniform operation of the plant is secured as all the variables are definitely and easily controlled, namely: Uniform feed of raw oil, a constant amount of cooling medium to the dephlegmator and a uniform temperature of hot oil leav-

ing the coil through a regulated amount of fuel to the burners in the furnace.

The presence of water in the raw oil, even up to 2 or 3 per cent, is neither troublesome nor dangerous in this process. When feeding the raw oil into the dephlegmator the water content is immediately vaporized and passes off with the hydrocarbon vapors, through the vapor line to the pressure distillate condenser and then into the receiving tank. Water at this point is drawn off at the lower level and the pressure distillate is drawn off at the higher level.

In the operation of the process the charging stock requires neither predistillation nor pretreatment nor careful selection. Crude oil having a large natural gasoline content should first be skimmed or topped of its natural gasoline in any efficient topping still. If the gasoline content in the crude is 10 per cent of less, then separate topping may be avoided, as it will occur automatically by feeding the crude oil direct to the dephlegmator in the process. For example, Healdton, Oklahoma crude oil has a natural gasoline content averaging about 8 to 12 per cent. Tarakan crude oil from Borneo 18 Bé. has no natural gasoline. The flash point is such that it does not require topping for direct use as fuel oil. Panuco Mexican crude has about 3½ per cent natural gasoline but to distill this out necessitates usually a 5 per cent or 6 per cent cut of the crude. Smackover 20 gravity crude has little, if any, natural gasoline. All these oils are handled in the crude state by the Dubbs still, and topping and cracking taking place in one operation.

The pressure distillate, which is the product of the process, is continuously withdrawn from the pressure distillate receiver tank and run to storage. It represents from 60 to 85 per cent of the total charging stock fed to the system. This pressure distillate requires acid treatment the same as benzine or gasoline from ordinary topping or skimming of crude oils, and should then be steam distilled to separate the gasoline from the heavier ends, consisting of kerosene and gas oil. The color after this treatment and steam distillation is clear white, and is without offen-

sive odor. It is practically undistinguishable from straight run topped gasoline. It will blend with any straight run stock.

The heavy ends of this pressure distillate (kerosene and gas oil or the gas oil fraction alone) may be again run to the process and be cracked, if desired, either separately or by mixing with the virgin charging stock, whatever it may be. The residuum is constantly withdrawn from the reaction chamber.

The residuum, as drawn from the reaction chamber, may be distilled to dry coke and the distillates therefrom may be rerun to the process for further cracking. The results of cracking this stock will be almost identical with the results of cracking virgin stock of gas oil gravity.

The coke is a porous, hard formation, usually containing less than one-half of 1 per cent of ash and is a most excellent fuel for use under boilers, for domestic purposes and for certain metallurgical applications. The residuum will have generally a zero or lower cold test and very low viscosity and is a fuel oil of high calorific value.

Pumps.—The pump equipment is very simple. One pump, the raw oil pump, delivers the cracking stock either direct to the heating coil, or by valve regulation, may send part or all of the raw oil to the top of the dephlegmator to supply the proper cooling medium for dephlegmation. A second small pump is used, should it be desired to recirculate pressure distillate to the top of the dephlegmator for cooling purposes.

The pyrometer equipment may be either one or two types namely:

a Leeds & Northrup Potentiometer Pyrometer.
b Brown Instrument Company.

One double recording temperature chart and two single charts are retained as a permanent record. A fourth instrument is of the multi-point contact type to obtain instantaneous readings at eleven locations and to check the recording instruments.

Temperatures are noted at the following points:

1, Furnace; 2, above the heating tubes; 3, below the heating tubes; 4, front end of tube chamber above the tubes; 5, rear end of tube chamber above the tubes; 6, combined feed line; 7, re-

flux line; 8, transfer line; 9, residuum line; 10, vapor line to dephlegmator; 11, vapor line to condenser.

Wires from the thermo-couple, at the point for temperature reading, to the instrument are encased in lead and rubber and are protected by galvanized conduit with weatherproof outlets. All instruments are mounted, upon a panel board, within the control house and are located directly in front of the operator.

The Universal Oil Products Company of Chicago, Ill., is the owner of the Dubbs Process. It licenses the process upon a royalty basis per barrel of throughput. The company guarantees the throughput, the yield and the correct performance of the plant, built in accordance with specifications furnished by it and constructed under its supervision.

Additional equipment necessary for the operations of the cracking plant not furnished by the lesser is covered by the following specifications.

(92-A) Charging Tanks.—Materials of construction for 30′ x 10′ tanks are to be the same as Section 76.

(92-B) Raw Oil Line Suction to Cracking Plant.—Same as P. D. pump out line, see Section 103-B.

(92-C) Recirculating Line at Charging Tank 92-A.—Pipe is to be black merchant pipe.

Screwed fitting should predominate and be medium weight C. I. screwed. All flanged fittings that are necessary should be standard weight C. I., faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Valves are to be standard S. E., O. S. & Y. gate valves having iron body and steel stems equal to Crane No. 464.

(93) Stack.—Materials of construction are to be the same as Section 4.

(93-A) Flue to Stack.—Materials of construction are to be the same as Section 3, except concrete mixture which is to be 1 : 2½ : 5. The necessary C. I. flue damper operated by a suitable worm gear should be provided.

(94) Coke Car (for Coke Removal at 82).—Each car is to have 1 cubic yard capacity and is to be of the side dump type.

Frame is to be made entirely of flat steel bars securely riveted at corners and thoroughly braced throughout. The hopper is to be made of steel plates and reinforced with structural steel angles. Loaded cars are to be held in an upright position by a suitable lock bar hinged to the rocker track. A suitable steel chain is to be provided to prevent the car from rocking too far when being dumped. The bearings are to be babbited with a superior metal composed of the following composition, tin—15 parts, lead—70 parts and antimony—15 parts.

The wheels are to be of a heavy pattern chilled cast iron, bored true and pressed on the cold rolled steel (turned true for bearings) axle.

Car is not to be equipped with brakes.

The coupling device at each end of the car is to consist of a bolt passing through the angle braces, so that the traction strain is evenly distributed.

In general the car is to conform to the following dimensions:

Capacity—1 cubic yard, length—6′ 4″, width—4′ 10″, height—3′ 9″, wheel base—3′ 6″, diameter of axle—2″, diameter of wheels—14″, track gage—24″, car frame flat bars—6″ x 3/8″, thickness of hopper plate—$^3/_{16}$″, weight of car—1,500 pounds each.

(94-A) Track for Coke Car.—Track is to be 24″ gauge.

Rails are to conform to A. S. C. E. standard, 25 lbs. per yard, rails.

Rails are to be laid on 6″ x 8″ prime cross ties properly spaced and made of southern pine. Ties are to be treated by the full cell process with a final retention of 12 lbs. of Grade No. 1 creosote oil per cubic foot.

(97-A) Sump for Emergency Drain Line No. 97.—Tank, which is to be cylindrical, size noted upon drawing (specify No.), must be set below grade (only roof projecting above grade), walls are to be of reinforced concrete of the following mixture:

One part Portland cement,

Two and one-half parts clean, sharp sand,

Five parts crushed limestone, maximum size—1½″ diameter.

Reinforcing rods are to be as specified in Section 1.

The necessary ferrules in tank wall for entrance of drains should be provided.

Roof is to be conical and air tight (provided with manhole and cover) made of $^3/_{16}''$ tank steel and supported with a central pipe column and structural steel rafters (conforming to standard specifications of Class "B" steel of the A. A. S. M.) riveted to a crown plate in the center above pipe column and anchored in the concrete walls of tank.

(97-B) Water Drain Lines (buried below frost line).—All drains are to be collected into one common sewer and connected to the main refinery sewer. Materials of construction are to be same as specified in Section 57.

(100) Residuum Line from No. 98 to No. 100-A.—Steam heating coil in residuum (100-A) storage tank is to be provided.

Black merchant pipe is to be used.

Fittings are to be medium weight C. I. screwed.

Valves are to be medium weight flanged O. S. & Y. gate valves —ferro-steel body, equal to Crane No. 505. F. & D. to A. S. M. E. 250 lb. standard dimensions—use $^1/_{16}''$ J. M. Seigelite ring-type gaskets or their equal.

(100-A) Residuum Storage Tanks.—Materials of construction for 30′ x 10′ tanks are to be the same as Section 76.

(103) P. D. Storage Tanks.—Materials of construction for 30′ x 10′ tanks are to be the same as Section 76.

(103-A) P. D. from Condensers.—Black merchant pipe is to be used.

Screwed fittings should predominate and are to be medium weight C. I. screw end.

Valves are to be standard flanged gate valves, O. S. & Y. iron body, steel stems, Crane No. 465 or equal. F. & D. to A. S. M. E. 125 lb. standard dimensions.

(103-B) Pump Out to Transfer Pump House from Tank No. 103. —Swing pipe in tank should be provided.

Black merchant pipe is to be used.

Fittings are to be medium weight C. I. screwed.

Valves are to be medium weight flanged O. S. & Y. gate valves, ferro-steel body equal to Crane No. 505. F. & D. to A. S. M. E. 250 lb. standard dimensions.

(104) Fire-Dikes Around All Storage Tanks.—Materials of construction are to be the same as Section 77.

(104-A) Fire Extinguishing Foam for All Tanks.—Same as Section 170.

(105-A) 2″ Steam Heating Coil for Residuum and Charging Tanks Only.—Same as Section 50.

(105-B) Smothering Steam Lines on All Tanks.—Same as Section 47.

(105-C) Gas Take-Off Line (on P. D. Tanks Only).—Same as Section 45.

(105-D) Drain Lines Under All Storage Tanks.—Same as Section 46.

(106) Standard Specifications for Circular Tanks.—The contractor for this material should furnish and erect in position, . . . tanks, with . . . gallons capacity below the overflow, diameter to be . . . feet, and . . . inches, and depth . . . feet . . . inches. This allows 12″ from center of overflow to top of tank.

Each tank should be made of mild steel plates ¼″ thick and weighing 10.2 pounds per square foot and of the quality known to the trade as Tank Steel. The cover (if required), should be No. 10 Steel, U. S. gauge weighing 5.67 lbs. per square foot, and of the quality known as Blue Annealed Steel. If the tank is 12′ or less in diameter, the bottom should be joined to the shell by means of flanging, if over 12′, a 3″ x 3″ x 5/16″ angle may be substituted at the option of the contractor. The upper edge of the tank is to be reinforced by a 3″ x 3″ x 5/16″ angle placed either on the inside or the outside of the tank, as may be decided.

All seams below the liquid line are to be single-riveted with ⅝″ rivets 2¼″ c/c., (c/c—center to center) rivets in stiffener angle are to be 8″ c/c. Cover is to be flat and entirely bolted with ½″ bolts 6″ c/c., and is to be stiffened every 4′ by a 2½″ x 2½″ x ¼″ angle, if tank is 12′ and under in diameter; if

over 12′ cover should be conical (½″ per 12″). (In the cover provide a hinged trap door 20″ square). Usual flanges are to be provided and are to be forged steel properly riveted in position. Size and location of flanges are to be determined by owner.

All field rivets are to be driven flat inside allowing a length equal to the diameter of the rivet for driving. The entire bottom is to be caulked inside, but the shell is to be caulked outside. All edges are to be properly bevel sheared and planed. *Split caulking will not be permitted.* All caulking must be done with a round-nosed tool.

After the work is entirely completed all debris and foreign material is to be removed and the inside of the tanks coated with suitable protective coating. The exteriors are to be properly painted with one shop coat of paint satisfactory to the owner.

After the tanks are completed, they should be filled with water (by the owner) and any leaks that may appear should be taken up by caulking.

Notes on Circular Storage Tanks.—Circular tanks are the more economical as the diameter and the depth approach each other.

Circular storage tanks for buildings are seldom large enough to warrant using plate over ¼″ thick if strength only is to be considered. For the sake of longevity, greater thickness is sometimes used.

Double riveting the girth seams on circular storage tanks is unnecessary, it merely increases the expense without adding any useful strength.

Thick plates are not necessary if the interior is treated with Bitumastic Enamel, which is guaranteed to maintain the tanks which it coats rust-proof and leak-proof for a period of ten years. (The pressure per square inch is found by multiplying the height of the liquid in feet by the pressure exerted at the base of a column of a similar liquid (@ 62° F.) 1 foot high).

Large storage tanks usually have an outside ladder, and a conical or umbrella roof. Roofs are usually No. 10. (The slope of conical roofs is usually 1½″ per 12″, while the radius of umbrella roof is always equal to the tank's diameter).

Roofs of either shape are self-supporting up to 25′ in diameter and up to 30′ if $^3/_{16}$″ plate is used.

Bottom Ls are usually ⅛″ heavier than bottom course. The bottom plate approximate two-thirds the thickness of the lower course.

Formula: $T = \frac{P\,r\,f}{\%\,S}$

In which:

T = Thickness of cylindrical shell plate in inches.
r = radius of cylindrical tank in inches.
f = factor of safety (5 is recommended).
S = Ultimate tensile strength of steel (55,000 lbs. per square inch is recommended).
P = Safe working pressure in lbs. per square inch.
%[1] = Efficiency of longitudinal seam.

(107) Standard Specifications for Rectangular Tanks.—The contractor for this material should furnish and erect in position tanks, with .... gallons capacity below the overflow. The length should be ... feet and ... inches, width ... feet ... inches, the depth ... feet ... inches. This allows 12″ from the center of the overflow to the top of the tank.

Each tank should be made of mild steel plates of the quality known to the trade as Tank Steel. Plates should be .... inches thick. (For method of specifying plates and weights see Section 76).

Tank is to be properly braced to prevent bulging or distortion. Braces must be bolted in position, no hook braces will be permitted.

Pan (if a pan is required for above tank) is to be $^3/_{16}$″ thick, weighing 7.65 lbs. per square foot. It should extend 6″ beyond the tank all around and be 4″ deep.

Cover (if required) should be made of No. 10 U. S. Gauge Steel, weighing 5.67 lbs. per square foot, and of the quality known as Blue Annealed Steel. The bottom or ends of the tank are to be flanged to rivet to the shell (angles are not to be used for this purpose). The corners are to be flanged hot to a radius of 3″.

[1] % = 0.70 the usual strength of a double lap riveted joint. (See Section 108.)

The top edge is to be reinforced by a 3″ x 3″ angle of the same thickness as the shell. The cover is to be entirely bolted with ½″ bolts, 6″ center to center and stiffened with ....x.... angles, every 4 feet. In the cover there is to be a hinged trap door 20″ square, with a catch and hasp. Usual flanges are to be provided. Size and location of flanges determined by owner.

All field rivets are to be driven flat inside, allowing a length equal to the diameter of the rivet for driving.

The entire bottom is to be caulked inside but the shell is to be caulked outside. All caulking edges are to be properly bevel sheared or planed. Split caulking will not be permitted. All caulking must be done with a round-nosed tool.

After the work is completed, all debris and foreign material is to be removed, and the inside of the tank coated with a suitable protective coating.

The exterior is to be properly painted with one shop coat of paint, satisfactory to the owner.

After the tanks are completed they should be filled with water (by the owner) and any leaks that may appear shall be taken up by caulking.

Practical Points.—Rectangular tanks are more economical as the shape approaches a cube. They should, however, be kept reasonably shallow as shallow tanks are much stronger.

If the height is 6′ or under, the plates should be ¼″ thick, weighing 10.2 lbs. per square foot if the height is between 6′ and 8′ the plates should be $^5/_{16}$″ thick, weighing 12.75 lbs. per square foot, if the height is over 8′ the plates should be ⅜″ thick, weighing 15.3 lbs. per square foot.

The strain on the walls of a rectangular tank are similar to those in a dam, reaching maximum at the bottom. Braces should be nearer together at the lower part of the tank than at the top.

Roughly speaking, braces are spaced about 4′ center, horizontally and varying vertically. For instance, a tank 5′ deep would be braced at the top only; one 6′ deep would have braces 3′ from the bottom and also at the top; one 7′ deep, braces 2′ from the bottom, 4½′ from the bottom, and also at the top; one 8′ deep, braces 2′ from bottom, 5′ from bottom, also one at top, etc.

Braces should preferably be made of 2½″ x ⅜″ flats, set on edge and blotted to a clip angle. Vertical braces are illogical as they are equally strong but not equally stressed at all heights.

Hook braces are dangerous and should be avoided.

If plates are ¼″ or 5/16″ thick, ⅝″ rivets 2¼″ center to center, should be used; if plates are ⅜″ thick ¾″ rivets 2½″ center to center should be used; rivets on top angle should be 8″ center to center.

Covers should be stiffened every 4′ by a 2½″ x 2½″ x ¼″ angle. If stiffener angle are over 10′ long, 3″ x 3″ x 5/6″ angle should be used.

Pans are usually made of 3/16″ steel, extending 6″ each side of tank, 4″ is the usual depth. An angle stiffener on the top edge is unnecessary on such shallow pans.

Double riveting of the seams on rectangular tanks is unnecessary, it merely increases the expense without adding any useful strength.

(108) Standard Specifications for Pressure Tanks.—The contractor for this material should furnish and erect in position ... tanks, ... feet and ... inches in diameter by ... feet ... inches in length, on the shell. The tanks are to be used for a working pressure of ... pounds per square inch. The shell is to be ... inches in thickness and made of mild steel of the quality known to the trade as Tank Steel. The heads should be...inches thick and made of mild steel, flange quality and dished to a radius equal to the diameter of the tank.

The longitudinal seams on the shell, should be (specify type of riveting) with a seam of approximately . . . . per cent of the efficiency of the solid plate. (A detailed calculation for pressure tanks is illustrated in Section 131).

The following represents the joint efficiencies of various types of riveted joints:

Single-riveted lap-joint efficiency	= *about 60 per cent.*
Double-riveted lap-joint efficiency	= *about 70 per cent.*
Triple-riveted lap-joint efficiency	= *about 80 per cent.*
Double-riveted butt-joint efficiency	= *about 83 per cent.*

Triple-riveted butt-joint efficiency = *about 88 per cent.*
Quadruple-riveted butt-joint efficiency = *about 94 per cent.*

Girth seams are to be all single-riveted, efficiency of seam is to be not less than 60 per cent.

Provide tank with a 11″ x 15″ pressed steel manhole, and also the usual flanges. Size and location are to be decided later.

All rivets are to be driven by hydraulic pressure with the exception of one girth seam and any C. I. flanges that it may be necessary to use, should be gun riveted.

All caulking edges are to be bevel-sheared or planed in the proper manner, and the tank tested with water at the works of the manufacturer to a . . . pounds (one and one-half times the working pressure) and made tight at that pressure.

After the work is completed, all debris and foreign material is to be removed and the inside of the tanks coated with suitable protective coating. The exteriors are to be properly painted with one shop coat of paint, satisfactory to the owner.

Practical Points.—Heads should be $^1/_{16}$″ thicker than shell in 36″ in diameter and under; ⅛″ thicker than shell between 36″ and 96″; and ¼″ thicker over that diameter.

If one head is reversed, as is sometimes necessary, or desirable, make the reversed head ⅛″ thicker than the normal head in sizes up to 72″, ¼″ thicker between 72″ and 96″, and avoid reversing the head in diameters greater than 96″ (as heads dished outwardly are 40 per cent stronger than those dished inwardly). Avoid screwed flanges for diameters over 6′, use nozzles instead.

The most satisfactory method of supporting pressure tanks is to set them on steel beams with C. I. saddle blocks, to furnish additional bearing and prevent them from rolling.

(109) Agitators.—The treatment of petroleum distillates with alkali and sulphuric acid is done by agitators, the agitation is effected either with compressed air or with circulating (centrifugal) pumps.

The agitators are vertical cylindrical tanks, having conical bottoms and are supported in various manners, *viz.;* brick, or reinforced concrete settings or structural steel supports.

The agitators when located in the open should be provided with steel roofs.

Agitators are fabricated of steel plates, and should be lined with antimonial lead when they are subjected to acid agitation. Antimony lead is preferred and 8-pound lead is generally used for the shell lining while 10-pound lead is used for the lining of the cone bottom.

THICKNESS AND WEIGHT OF SHEET LEAD.

1 lb.	per	square	foot	—	equals	—	$^1/_{64}$	inch.
1½ lb.	"	"	"	—	"	—	$^1/_{43}$	"
2 lb.	"	"	"	—	"	—	$^1/_{32}$	"
2½ lb.	"	"	"	—	"	—	$^1/_{24}$	"
3 lb.	"	"	"	—	"	—	$^3/_{64}$	"
4 lb.	"	"	"	—	"	—	$^1/_{16}$	"
6 lb.	"	"	"	—	"	—	$^3/_{32}$	"
8 lb.	"	"	"	—	"	—	⅛	"
16 lb.	"	"	"	—	"	—	¼	"
30 lb.	"	"	"	—	"	—	½	"

SPECIFICATIONS FOR A 22′ x 24′ AGITATOR.

Size.—The agitator is to be 22′ diameter x 24′ high.

Type.—The agitator is to be (cylindrical) vertical style.

Fabrication.—The shell of the agitator is to be made in three courses, (four plates to a course). The cone bottom is to be riveted to the shell and to have a 30 degree slope.

Setting.—The agitator is to be supported with a brick setting in which are located four doorways on 90-degree centers.

Steel plates.—The agitator plates are to be of the following thickness:

Cone bottom	7/16″	thick.
First ring	3/8″	"
Second ring	5/16″	"
Third ring	1/4″	"
Roof	1/4″	"

All plates are to conform to the specifications adopted by the Association of American Steel Manufacturers.

Only the best quality of tank steel should be used in constructing the shell of the agitator, and in the cone bottom use only the best quality of flange steel.

Riveting.—The agitator is to be single-riveted throughout, except the cone bottom which must be double-riveted.

Five-eighth inch rivets should be used in roof and shell.

Three-fourth inch rivets should be used in cone bottom.

Roof.—The roof of the agitator is to be of the globe type, and provided with a ventilator and four explosion doors 18″ square.

Walkway.—The agitator is to be provided with a walkway running completely around the shell, also a ladder to connect this walkway with the ground.

Caulking.—The roof is to be caulked on outside. The shell of the agitator (*i. e.*, the height of 24′) is to be caulked acid tight both inside and outside. The cone bottom is to be caulked on inside.

Fittings.—The agitator is to be provided with fittings of such size and location as desired by the owner.

Painting.—Agitator is to be given one outside coat of graphite paint.

(110) Specifications for an Acid Storage Tank.—(Acid tanks are used in connection with the treatment of light oils).

Size.—The tank is 8′ diameter x 25′ long.

Type.—The tank should be a cylindrical horizontal tank.

Shell.—The tank shell is to be fabricated in three courses. Two plates to each course.

Heads.—The heads are to be of $^7/_{16}$″ flanged and dished to a radius equal to the tank diameter.

Material.—The steel plate and rivets used in fabricating this tank must conform to the specifications adopted by the Association of American Steel Plate Manufacturers. The shell is to be $^5/_{16}$″ tank steel throughout; the heads are to be $^7/_{16}$″ flange steel.

Riveting.—The longitudinal seams are to be double-riveted, and all girth seams are to be single-riveted. The rivets are to be ⅝″ diameter, 2½″ pitch.

Caulking and Testing.—The tank is to be caulked both inside and outside. The tank is to be tested with water one and one-half times the safe working pressure desired and made tight at that pressure. All caulking must be done with a round-nosed tool.

Fittings.—Tank is to have a 20″ man-head, (with cover) located on top, also any other flanges that the owner may desire. All flanges are to have tapered threads.

Painting.—Tank is to be given one outside coat of graphite paint.

(111) Model Specifications for a 10′ x 40′ Steam Still.—*Size.*—The steam still is to be 10′ in diameter x 40′ long.

Type.—The steam still is to be of a horizontal type.

Fabrication.—The shell is to be made in four courses, two plates to a course. The heads are to be hemispherical, flanged in and riveted to the shell. This still will not have any supporting lugs, but will be supported by five brick walls.

Plates.—The shell of the still is to be made of ⅜″ tank steel, the heads of ⅜″ flange steel both conforming to the specifications adopted by the Association of American Steel Manufacturers.

Riveting.—The girth seams are to be single-riveted. Longitudinal seams must be double-riveted, use ¾″ diameter rivets throughout.

Caulking and Testing.—All plates are to be sheared for caulking throughout on the outside. After completion the still is to be tested with water and made absolutely tight.

Fittings.—The still is to be provided with a 20″ man-head where shown upon the drawing, also any other pipe flanges that the owner may desire should be forged steel boiler flanges, having standard pipe threads.

Painting.—After completion, the still should be given one outside coat of a good quality of heat-resisting paint.

(112) Steam Still Settings.—The three alternates given below have been used extensively.

(*a*) *When Made of Brick.*—(See Fig. 2). The brick used should be a good quality, hard, and well burned red brick. The sand should be a clean, sharp, grit sand, and free from loam or dirt. The cement mortar should be made of one part of Portland cement and not more than four parts of sand, and should be used immediately after being mixed.

(*b*) *When Made of Reinforced Concrete.*—Steel reinforcing rods should be plain or deformed round bars, conforming to latest specifications of A. S. T. M. billet steel construction reinforcement structural grade. Concrete should be made of at least one part of Portland cement, two parts of sand, and five parts of clean, broken stone, of such size as to pass in any way through a two-inch ring, or good, clean gravel may be used in the same proportion as broken stone. The cement, sand and stone or gravel should be measured and immediately used after being mixed. All concrete when in place should be properly rammed and allowed to set without being disturbed.

(*c*) *When Made of Structural Steel.*—Steel work is to be in accordance with American Society for testing materials specifications A-9-21 structural steel for buildings. Workmanship and details are to be in accordance with manufacturer's specifications, subject to approval. All steel work sohuld be given one shop

coat of approved red lead paint, also one field coat of same material is to be applied at least four days before erection.

(*d*) *Note*:—The footing courses for above three cases are to be made of stepped up brick or reinforced concrete proportioned to safely carry the load of the still and in proper relation to the bearing capacity of the soil upon which they rest.

(113) Insulation for Steam Stills.—A 2½″ thickness of asbestos blocks with broken joints should be laid against the steel shell. Upon this apply a ¼″ rough coat of asbestos cement filling in all joints of asbestos blocks. Next apply 1″ hexagon galvanized chicken wire and over this apply a ¼″ scratch coat of asbestos cement, and finish with a ½″ coat made of 30 per cent of Portland cement and 70 per cent of asbestos cement, similar to J. M. No. 302. The insulation is to be supported similar to the method used in Section 13.

(114) Vertical Towers for Steam Stills.—Materials of construction are to be same as Section 11.

When towers are used as scrubbers, they should be filled with stones or tile, which are usually supported with a C. I. grid held in position by a steel angle riveted to shell.

When towers are used as dephlegmators, the necessary baffles should be provided.

The towers should be provided with a suitable steel ladder, that will extend to the full height of the towers.

(115) Heat Exchanger for Steam Stills.—Materials of construction are to be same as Section 9, except that the heat exchanger should be of the vertical type.

(116) Vapor Lines.—Materials of construction are to be same as Section 29.

(117) Telltale Column.—Materials of construction are to be same as Section 26, except space test cock on 6″ centers.

(118) Condenser Coil for Steam Stills and Condenser Box Shell.—Materials of construction are to be same as Section 25, and 7 respectively.

(119) Tail Lines for Steam Stills.—Materials of construction are to be same as Section 33.

(120) **Receiver House for Steam Still.**—Same as Section 8.

(121) **Vacuum and Relief Valves for Steam Stills.**—Same as Section 27.

(122) **Cold Distillate Line.**—Materials of construction are to be same as Section 14.

(123) **Hot Distillate Line.**—Materials of construction are to be same as Section 16.

(124) **Bleed Line.**—Materials of construction are to be same as Section 30.

(125) **Cooling Box Shell.**—Materials of construction are to be same as Section 10.

(126) **Cooling Coils.**—Materials of construction are to be same as Section 48.

(127) **Low Pressure Steam Line.**—Materials of construction are to be same as Section 59.

(128) **Exhaust Steam Line.**—Materials of construction are to be same as Section 61.

(129) **Open and Closed Coils.**—Materials of construction are to be same as Section 49.

(130) **Residuum Line from Still to Cooler Box.**—Black merchant pipe and standard black nipples threaded at both ends should be used.

The nipples screwed into the stills must be X-heavy.

Flanged fittings (where used) must be cast steel faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Screwed fittings should predominate and must be X-heavy malleable iron equal to Crane 600 lbs. screwed-end fittings.

Valves are to be standard gate valves cast steel body, bonnet and disc, with C. I. yoke steel stem and nicaloy seats, similar to Crane 47B or its equal, the flanges are to be faced and drilled to the A. S. M. E. 125 lb. standard dimensions.

Gaskets must be J. M. $^1/_{16}''$ Service ring-type or its equal. Covering is to be same as recommended in Section 16.

(131) **Fullers' Earth Filters.**—Fullers' earth filters are used to remove impurities, from illuminating oil, cylinder oil, and lubricating oil. (See Fig. 7.)

The filters are usually 8 feet in diameter x 25 feet high and completely filled with fullers' earth, through a manhole located in the upper head of the filter, which is bolted down before the oil to be treated, is allowed to enter. (For detail see Fig. 6.) Some refineries use the same fullers' earth ten times over, in one instance the same earth was used sixteen times, and the only treatment that the earth receives after each service is to regenerate it in a kiln especially designed for the purpose.

There are two types of regenerators, *viz*: the horizontal rotary type and the vertical type. The horizontal rotary type is the one most commonly used.

The air pressure usually applied in the filters to percolate the oil through, is about 5 to 15 pounds per square inch, depending upon the gravity of the oil, however, the filters should be designed for a working pressure of about 50 pounds per square inch.

Calculations for an 8-Foot x 25-Foot Filter.

Designed for a Safe Working Pressure of 50 lbs. per sq. in.

$$t = \frac{Pdf}{2eT} \qquad e = \frac{as}{ptT}$$

In which:

t = Plate thickness, in inches.
P = Safe working pressure, lbs. per sq. in.
d = Diameter of filter, in inches.
f = Factor of safety (safe to use 4).
e = Riveted joint efficiency.
T = Ult. tensile strength of steel lbs. per sq. in. (safe to use 55,000 lbs. per sq. in.).
S = Ult. shearing resistance of rivet lbs. per sq. in. (safe to use 45,000 lbs. per sq. in.).
p = Pitch of rivets in inches.
a = Area of rivet hole in sq. in.

In substituting the above values then,
assuming $t = {}^5/_{16}''$; $p = 2''$; $a = 0.37''$; $P = 50$ lbs. per sq. in.

$$e = \frac{0.37 \times 45{,}000}{2 \times {}^{5}/_{16}'' \times 55{,}000} = \text{very nearly } 0.49$$

$$t = \frac{50 \times 96 \times 4}{2 \times 0.49 \times 55{,}000} = 0.35'' \text{ or } {}^{5}/_{16}''$$

(132) Loading Racks.—Loading racks for loading tank cars should be constructed of wood, steel or reinforced concrete.

The loading rack tracks should always be laid level, otherwise proper measurement of oil will be difficult.

For Wood Constructed Loading Racks.—They are usually made of 4″ x 4″ spruce posts, 10′0″ centers and 2″ x 4″ spruce cross and longitudinal bracings and hand rail.

The walkway is made of 2″ spruce planks, and the 4″ x 6″ sill is to be properly anchored (with satisfactory anchor bolts) in the concrete footings. Footings should be similar to Section 112-d.

For Steel Construction.—They are to be similar to structural steel steam still settings, Section 112-c.

For Reinforced Concrete Construction.—They are to be made similar to reinforced concrete steam still settings, Section 112-b.

(133) Run-Down Tanks for Fullers' Earth Filters.—To be constructed as per Section 107.

THE COLD SETTLING PROCESS.

The cold settling process and subsequent filtering for making bright stocks from cylinder stocks, consists briefly as follows:

Special naphtha is pumped from a tile-jacketed storage tank, into a mixing tank where the cylinder stock is mixed with the naphtha, (cylinder stock tanks are to be provided with a heating coil.) From this tank the mixture is pumped to a storage mixture tank and thence to the filters and is filtered to the desired color. From the color tanks, it is pumped to the cold settling tank which is insulated with cork boards or hair felt and encased in a tile jacket and equipped with a refrigerating coil.

After the proper temperature has been reached the mixture separates in two layers during the settling period, the refrigeration is stopped and the upper portion is drawn off through the adjustable swing pipe suction and is heated in steam stills in order to reclaim the naphtha which may be recycled. The residuum in the steam still is the low cold test bright cylinder stocks, which is compounded into various grades of automobile and cylinder oils. The lower portion, known as petroleum grease, also known as petrolatum is drawn off through the petrolatum suction and is also steam-stilled in order to reclaim the naphtha. It is then filtered to produce the different colored petrolatums. Sections from 134 to 140 incl., cover specifications for the cold settling process.

Many refineries are adopting the centrifuge process in preference to the slow cold settling process, due to the better yield of lower cold test bright stocks and producing a much better quality of petrolatum.

Fig. 4 illustrates the Sharples centrifuge process for manufacturing bright stocks. Sections from 140 to 164 incl., cover specifications for the centrifuge process.

(134) Cold Settling Tank.—The tank is to be a vertical cylindrical tank, 20 feet in diameter x 20 feet high. Capacity is to be 45,000 gallons or 1,000 42-gallon barrels.

All plates are to be grade "A" open hearth tank steel conforming to the standard specifications of the Association of American Steel Manufacturers.

The tank is to be made in four rings each of equal height.

First ring to be No. 6 gauge, weighing 8.28 pounds per square foot.

Second ring to be No. 7 gauge, weighing 7.65 pounds per square foot.

Third ring to be No. 8 gauge, weighing 7.01 pounds per square foot.

Fourth ring to be No. 8 gauge, weighing 7.01 pounds per square foot.

The bottom is to be No. 7 gauge, weighing 7.65 pounds per square foot.

The roof is to be No. 12 gauge, weighing 4.46 pounds per square foot.

The bottom angle ring is to be 2½″ x 2½″ x $^5/_{16}$″.

The top angle ring is to be 2″ x 2″ xx ¼″.

All horizontal girth seams are to be single-riveted.

All vertical seams are to be double-riveted.

All seams are to be caulked with a round-nosed tool.

Manhole is to be 20″ in diameter and located in center of first ring.

Flanges are to be forged steel boiler flanges with standard tapered pipe threads, location of flanges are to be approved.

Ten sample trial cocks spaced on 12″ centers (projecting 12″ beyond tank shell) commencing from the tank bottom should be provided.

Tank is to be furnished with a suitable size swing pipe, complete with a wire rope and windlass.

Roof is to be supported by a series of radial structural rafters of proper size and supported by one central pipe column of proper size.

Tank should be painted with one coat of a good quality of red metallic paint and after completion the exterior surface should be given two additional coats of red metallic paint.

Upon completion the tank is to be tested when full of water and caulked tight and dry.

(135) Insulation for a One Thousand-Barrel Cold Settling Tank. A 2″ layer of nonpareil cork board is to be laid against tank shell

after which the cork board surface is to be given a coat of asphalt cement. (Some refineries use a layer of hair felt in place of the cork board). Then completely incase, the entire tank (except roof) with an 8″ thickness of standard size hard-burned common red brick or with 12″ x 12″ x 8″ good quality hard-burned hollow tile, (use smooth faced hollow tile).

The cement used should be made of one part of Portland cement and not more than four parts of clean, sharp sand. The cement is to be used immediately after being mixed. The roof (exterior area) surface is to be insulated with two 2″ thickness of nonpareil cork board laid against the tank roof shell with a coat of asphalt cement between the two layers, and also applied to the outer surface over which is to be laid an approved weather proofing.

(136) Brine Circulating Coils (to be Set in Roof of Cold Settling Tanks).—The coils are to be made of extra heavy 1¼″ wrot-iron pipe (require 3 lineal feet of pipe per each 40 gallons of the tank's contents).

Fittings are to be screwed-end standard malleable iron fittings.

Unions are to be standard flanged malleable iron.

Flanged joints should always be used in preference to screwed joints wherever possible.

Gaskets are to be $^1/_{16}$″ thick Garlock No. 122 (made of red rubber sheets) or equal.

Valves and cocks are to be all brass and when installed in the line, should be provided with short nipples (with malleable iron flanged unions) on either side, so that it will be unnecessary to restore the entire line which corrodes when brass is coupled with wrot-iron.

To insure a perfectly tight joint, a thin paste of litharge and glycerine should be applied on all pipe threads.

(137) Structural Supports for Suspending Brine Circulating Coils.—The steel work should be in accordance with American Society for Testing Materials specification A-9-21 structural steel for buildings. Workmanship and details should be in accordance with manufacturers' specifications, subject to approval.

The structural steel composing these supports should be given one shop coat of red lead and oil and one field coat of bitumastic paint.

(138) **Cold Settling Tank Foundation.**—The concrete mixture should be:

One part of Portland cement,
Three parts of clean, sharp sand,
Six parts gravel maximum size 2 inches.

The reinforcing rods that are necessary should be plain or deformed round rods, conforming to specifications of A. S. T. M. billet steel construction, reinforcement structural grade. A coat of asphalt cement should be applied upon the concrete foundation, then lay two 2″ layers of nonpareil cork board throughout the area to be occupied by the tank with asphalt cement between each layer and upon top surface before tank is set in place.

(139) **Petrolatum Suction Pipe.**—To guarantee an evenly distributed suction, the suction pipe is to be made in the form of a cross, having pipe caps on extreme ends and perforations staggered on the underside throughout each fork.

Pipe is to be standard black merchant pipe.

Medium weight cast iron screwed fittings should be used.

Flanged fittings and companion flanges (where necessary) are to be standard cast iron, faced and drilled to A. S. M. E. 125 lb. standard dimensions.

Cut-off valves are to be standard flanged gate valves, I. B. B. M. with steel stems faced and drilled to A. S. M. E. 125 lb. standard dimensions and are to be packed for oil.

Gaskets are to be $^1/_{16}$″ J. M. Seigelite ring-type or equal.

(140) **Brine Pumps.**—Brine pumps are to be horizontal duplex double-acting piston-pattern steam pumps with steam end standard duplex design, while fluid ends are to be brass fitted.

Specifications for a 300-barrel Sharples centrifugal plant for manufacturing bright stocks from cylinder stocks. (Fig. 4).

The type of building and general layout of equipment should suit local conditions.

The centrifugal equipment necessary is fifteen individually motor belt driven super centrifuges.

REFRIGERATION.

(*a*) One 120-ton refrigeration plant.

The temperature of the brine is not to exceed minus 20° F. on the outlet side of the brine cooler.

(*b*) The minimum quantity of minus 20° F. brine required is 180 gallons per minute.

(*c*) The work to be done consists of chilling 104,700 gallons of oil (a mixture of 35 per cent lubricating stock and 65 per cent naphtha) from 100° F. to minus 10° F. through a period of 48 hours.

(*d*) Specific gravity of oil mixture—0.80.
Specific heat of oil 0.5.

TANKS.

(All capacities in 50-gallon barrels.)

(141) Blending and Heating Tank.—(*a*) One tank is to hold at least 1,254 barrels, gross capacity. Tank is to be of ¼″ steel.

(*b*) This tank is to be equipped with heating coils to raise the temperature of the oil to 115° F. over a period of five hours, and a mechanical agitator to insure perfect solution without loss of naphtha. Roof supports and agitator are to be of same design as for chilling tanks.

(*c*) Tank is to be provided with a thermometer well located 4″ from the bottom for angle thermometer.

(*d*) A 6″ flange should be located in bottom ring of tank to receive charging line for stock and naphtha. A 6″ flange should be located at bottom of tank for pump-off line. Four 2″ flanges should be located in bottom ring of tank 1′ from tank bottom for double steam coil connections.

(142) Chilling Tanks T-2, T-3, and T-4.—(*a*) Three tanks, 1,254 barrels, gross capacity, in addition to cone bottom. Net capacity required 1,047 barrels.

Size is to be 22′ diameter x 22′ high with 12″ cone bottom. Tank is to be of $^5/_{16}$″ steel.

(*b*) These tanks are to be insulated on bottom and sides with 6″ of 3-ply 2″ cork lagging and on roofs with 4″ 2-ply cork lagging or 6″ of ground cork. Cork is to be applied after the tanks have been tested for leaks and the exterior surfaces have been painted or coated with asphalt. All insulated tanks should be given the same treatment.

(*c*) Each tank is to be provided with a thermometer well located three feet from the bottom for installation of angle thermometer, the thermometer bulb is to extent not less than 2 feet inside of tank. Recording thermometers while not essential will assist in securing uniform results.

(*d*) The discharge connection should be 4″ and should be made at the bottom. The discharge line must drain from the tank to Pump P-9 and must be free from pockets and traps.

(*e*) The charging line to the chilling tanks should be 6″ and should enter through the bottom ring of the tank and have two block valves with a bleeder between.

(*f*) Each tank should be provided with 5,643 feet of 2″ steel coil for chilling brine. The chilling brine connections at the inlet and outlet of the tank should be 3″.

(*g*) Each chilling tank is to be equipped with an agitator. The agitator should be operated about one hour immediately before the tank is charged with warm oil and thereafter about ten minutes each hour at regular periods for 48 hours to insure uniform temperature and prevent stratification in chilling.

(*h*) Each chilling tank should be vented to the outside of the building and the vent line protected with two sections of fine wire gauze.

(*i*) Each chilling tank should be grounded with one strand of No. 3 copper wire.

(143) Wax-Free Oil Run-Down Tank T-6.—(*a*) One tank 22′ diameter x 10′ high, five hundred and seventy barrels gross capacity. This tank has no agitator. Tank is to be of ¼″ steel.

(*b*) This tank should be insulated on bottom and sides with 4″ 2-ply 2″ cork lagging and on the roof with 2″ 1-ply cork lagging.

(*c*) The inlet should be located on the roof and should be 4″ in diameter and should be drained from the centrifuges to the tank with as uniform a grade as possible leaving no traps or pockets in the line. This line should be insulated with cork standard brine covering.

(*d*) There should be two 2″ flanges located on the front side in the bottom ring for the recovery coil connections.

(*e*) The outlet should be connected in the center of the bottom and should be 3″ in diameter. It is not necessary to insulate the discharging line. The discharging line is to be carried to pump P-7 three inches and thence to storage tanks. Place 3″ gate valve on discharge line at the tank connection.

(*f*) In the bottom of this tank install 1,500 feet of 2″ pipe recovery coil.

(144) Carrier Liquid Tank T-9 (Hot Water).—(*a*) One tank 8′ wide x 8′ long x 7′ high, sixty-seven barrels capacity. Tank is to be of ¼″ steel.

(*b*) Bottom and sides next to wall should be insulated with 4″ hair felt, on exposed sides with 2″ hair felt. Exposed sides should be protected with 6″ hollow smooth-faced tile.

(*c*) Two 2″ flanges should be located 6″ from the bottom for steam coil connections. One 2″ flange for fresh water supply on roof. One 3″ flange for carrier liquid outlet 6″ from bottom next to pipe tunnel for pump connection. One 6″ flange 3′ from bottom on side next to separator tank T-8 for water inlet. Flange should be provided on end of tank 2′ from bottom for angle thermometer. One 2″ flange should be located 2′ from bottom of tank for installation of thermostatic regulator ("Sarco" recommended). One 2″ flange should be located on side of tank for skimming line connection.

(*d*) The roof of tank is to have an opening at the end to be the full width of tank by 3 feet. This opening is to be closed with a removable wooden cover. Tank is to be vented.

(*e*) One hundred and twenty-five feet of 2″ steam coil should be installed in bottom of tank. A Sarco temperature regulator should be installed for controlling inlet to the steam coil. The temperature of the water is to be maintained at 135° F. A

strainer of 50-mesh should be placed in the steam line ahead of the temperature regulator. This strainer should have at least 15 square inches of surface and should be installed with a heavy supporting screen behind it. The outlet of the coil is to be arranged to discharge condensed water either to sewer or to tank to add distilled water to system when necessary.

(145) Separator Tank T-8 (Hot Water and Wax).—(*a*) One tank 8′ x 8′ x 7′ high, sixty-seven barrels capacity. Tank is to be of ¼″ steel.

(*b*) Bottom and sides next to wall should be insulated with 4″ hair felt, on exposed sides with 2″ hair felt. Exposed sides should be protected with 6″ hollow smooth-faced tile.

(*c*) Two 2″ flanges should be located 6″ from bottom for steam coil connections, one 4″ flange for wax-water inlet on roof, one 6″ flange 6″ from bottom on side next to water tank T-9, one 4″ flange 6″ from top of center of side next to T-7 for wax overflow. Flange should be located 2′ from bottom of tank for angle thermometer.

(*d*) The roof of tank is to have an opening at the end to be the full width of tank by 3 feet. This opening is to be closed with a removable wooden cover. Tank is to be vented.

(*e*) One hundred and twenty-five feet of 1″ steam coil should be installed 6″ from bottom of tank.

(146) Wax Tank T-7.—(*a*) One tank 8′ x 8′ x 7′ high, sixty-seven barrels capacity. Tank is to be of ¼″ steel.

(*b*) Bottom and sides next to wall should be insulated with 4″ hair felt, on exposed sides with 2″ hair felt. Exposed sides should be protected with 6″ hollow smooth-faced tile.

(*c*) Two 2″ flanges should be located 6″ from bottom for steam coil connections, one 4″ flange 6″ from top next to separator tank T-8 for wax inlet, one 3″ flange on bottom next to pipe tunnel for wax pump-off line, one 2″ flange on side of tank 2′ from bottom for angle thermometer.

(*d*) The roof of tank is to have an opening at the end to be the full width of tank by 3 feet. This opening is to be closed with a removable wooden cover. Tank is to be vented.

(*e*) One hundred and twenty-five feet of 1″ steam coil should be installed 6″ from bottom of tank.

(147) Elevated Oil Supply Tank T-12.—(For ground-level chilling tank installation) (*a*) One tank 7′ x 7′ x 5′ high, thirty-seven barrels capacity, is to be of ¼″ steel.

(*b*) Sides, bottom and roof should be insulated with 6″ 3-ply 2″ cork lagging.

(*c*) One 20″ manhole should be located on roof.

(*d*) One 1½″ flange should be located on roof for vent and switch control rod.

(*e*) One 4″ flange should be located on side of tank 12″ from bottom for inlet.

(*f*) One 4″ flange should be located in center of bottom for discharge.

(*g*) This tank is to be equipped with a float operated electric switch which controls the starting and stopping of supply pump P-9, Cutler Hammer float and switch recommended.

(*h*) Thermometer well should be located in line between tank T-12 and centrifuges, in an easily accessible position.

(148) Constant Level Tank T-5.—(To be used when chilling tanks are installed one floor above centrifuges.)

(*a*) Round tank 2′ diameter x 2′ high (above cone).

(*b*) Top, bottom and sides should be insulated with 6″ of cork. Top of tank is to be easily removable with insulation.

(*c*) A 4″ float valve should be installed to control line from chilling tanks to Tee in bottom of tank T-5. Float in tank T-5 should be round ball 12″ in diameter.

(*d*) A 4″ flange should be located at point of cone bottom for inlet and outlet.

(*e*) A thermometer well should be provided in an accessible position between tank T-5 and centrifuge.

(149) Slop Tank T-11.—(*a*) One tank 8′ 0″ x 8′ 0″ x 7′ 0″ high, sixty-seven barrels capacity, is to be of ¼″ steel.

(*b*) Roof of tank is to be fitted with 20″ manhole and 2″ vent. Locate 2″ flange in bottom of tank for water draw-off. Locate 3″ flange in side of tank 6″ from bottom for oil pump-off.

(*c*) It is not necessary to insulate this tank.

(150) Agitators.—(*a*) Each chilling tank is to be equipped with an agitator.

(*b*) Jack and line shaft $2^{3}/_{16}''$ in diameter should be provided as shown on plans. Shaft is to extend past blending and heating tank and chilling tank. Locate adjustable wall brackets opposite each pulley and at intermediate points. Use chain sprocket on line shaft for drive to pinion shaft. This sprocket is to be fitted with a jaw clutch and operating levers so that any one tank may be agitated independently of any other.

(*c*) A 6″ belting to line shaft should be used.

PUMPS.

(151) P-1 Raw Dilute Oil Pump.—Capacity 375 gallons per minute, 100′ head.

This pump may be either double-acting steam-driven duplex or motor-driven rotary. (See Section 68).

The suction from the mixing tank T-1 is to be 6″, the discharge to the chilling tanks 6″. The discharge line enters through the bottom ring of the chilling tanks as heretofore specified. Place two valves in the line at the chilling tank connection with a bleeder between. It is not ordinarily necessary to cover this line.

(152) P-1a Stock and Naphtha Pump.—This pump is to be used in charging the heating and blending tank with filtered stock and naphtha.

This pump is to be of same specifications as P-1 and is to be manifolded at the pump on both suction and discharge so that P-1 and P-1a may be used interchangeably for either job.

(153) P-2 Refrigerator Brine Pump.—This pump is a part of the regular refrigeration equipment and can be supplied by the manufacturer of refrigeration equipment. (See Section 140). The capacity should not be less than 180 gallons per minute.

The discharge from this pump should not be less than 4″ diameter on the discharge side of the brine cooler, the line is to be run 4″ past pumps P-3, P-4, and P-5 and then is to be equipped with one 4″ relief valve set for 40 pounds pressure and relieving into the cold brine storage tank T-10. Three 4″ x 4″ x 3″ T's should be located in the line past the relief valve to receive the

brine overflow from the chilling tank coils. A thermometer well should be located on the line at some accessible location.

(154) P-3, P-4, and P-5 Brine Circulating and Mixing Pumps.—Capacity 120 gallons per minute. Head 100′.

Brine triplex pumps—Silent chain or gear motor driven, 3″ suction, 3″ discharge.

Discharge from these pumps to bottom of chilling tank coils is to be 3″. Valve should be located close to the pump discharge. At the discharge from the top of the coil place a T. From the bottom of this T, the line returns to the pump suction 3″. The overflow of spent brine from the coil is to be taken off at the top of the T, which is to be the highest point in the line, and is to be divided into two lines, one 3″ returning directly to the main brine return line, the other 2″ passing to a header leading to either the pipe recovery coil in the bottom of the wax free oil run-down tank T-6, or to a heat exchanger.

Cold brine will be supplied to each tank circulation system through 3″ lines leading to the suction of P-3, P-4, and P-5. Three-inch valves should be placed in these lines close to the pumps. A 1″ by-pass should be arranged past the 3″ valve for delicate adjustment of flow. In this 1″ by-pass line, locate a 1″ valve. All lines are to be insulated with special, thick, brine covering.

A thermometer is to be placed in discharge of pump and in return line from tank coil.

(155) P-6 Carrier Liquid Hot Water Pump.—Capacity 50 gallons per minute, head 100′.

Triplex or double-acting steam duplex—silent chain or gear-driven triplex recommended. Three-inch suction line from tank T-9, 3″ discharge from pump carried along ceiling over lines of centrifuges and well secured to I-beams. Suction line should have a 30-mesh strainer of at least 1 square foot area. There is to be a 3″ x ½″ Tee 2 feet to the right of center line of each centrifuge for individual feed. After passing centrifuges, the line is to be run vertically for 20′ and there provided with 6′ of 4″ open end stand pipe and 4″ overflow back to tank T-9. Connections from this header to centrifuges are to be ½″, to extend

down to 15″ above level of water connections on centrifuges. The ½″ line is to be equipped with a valve 3″ from end of line. Connections from ½″ line to union on centrifuge are to be made with flexible hose with union attachment at centrifuge.

(156) P-7 Wax-Free Oil Pump.—Capacity 60 gallons per minute, 200′ head. (This head should be checked against the distance to and elevation of storage tanks for wax-free oil.) Steam pump or motor driven rotary. Three-inch suction from run-down tank T-6 to pump. This suction should drain to pump and be free from traps and pockets. Three-inch discharge from pump to storage tanks.

It is not necessary to cover these lines.

(157) P-8 Wax Pump.—Capacity 40 gallons per minute. Head 200′. (This head should be checked against the distance to and elevation of storage tanks.) Steam pump or motor driven rotary. Three-inch suction from tank T-7, and 3″ discharge to storage. Suction and discharge are to be equipped with steam core or means of blowing clean. It is not ordinarily necessary to insulate these lines.

The overflow lines from tank T-8 to tank T-9 should be 6″, and to tank T-7 should be 4″. The water overflow should run from the flange 6″ from the bottom of tank T-8 through the flange 3′ from the bottom of tank T-9 and up to within 1″ of the level of the wax overflow from tank T-8. The wax overflow should be connected directly across from 6″ below the top of tank T-8 to tank T-7 at the same level or with a slight grade to tank T-7.

(158) P-9 Chilled Oil Supply Pump.—Kinney Pump, electric motor driven, chain transmissions, working pressure 50 pounds. Size 6 x 4 x 6. Standard capacity at 200 r. p. m., 84 gallons per minute. It is to be geared down to operate at 180 r. p. m., to pump 75 gallons per minute.

Four-inch suction from chilling tanks T-3, T-4, and T-5. This suction line must not be manifolded at the pumps. The operating valves for the three chilling tanks must be placed as close to the tank connections as practicable and the suction line run as

one header for the three tanks, draining from the farthest tank to the pump, and must be free from traps and pockets.

A block valve should be placed at the suction header on each tank connection so that before a fresh tank is cut in, the line may be drained and blocked off to prevent wax settling in the dead portion of line.

Four-inch discharge to supply tank T-12 to enter T-12 in side 12″ from bottom. Place 4″ swing check valve in line between P-9 and T-12. From tank T-12 the feed header to the centrifuges should be 4″ and should be run back of the centrifuges 15″ above the level of the centrifuge base with a 4″ x 4″ x ¾″ T located 18″ to the left of the center line of each machine. The centrifuge connections for this header are to be ¾″ and must be taken off at bottom of header so as to drain header into machines to prevent accumulation of wax. Locate ¾″ valve near union on feed pipe. Tank T-12 should be equipped with 4″ emergency overflow installed on a grade to raw dilute stock tank.

A double strainer is to be placed on discharge line between T-12 and centrifuges. This strainer is to have gate block valves to control flow through either strainer.

Suction and discharge to the pump, also feed lines to centrifuges should be insulated with special, thick, cork brine covering.

Pump P-9 is operated by an electric float control switch located in tank T-12. Cutler Hammer recommended.

(159) Slop Tank Pump.—Capacity 50 gallons per minute. Head 100′.

Steam duplex or rotary. Three-inch suction from slop tank T-11, 3″ discharge to blending and heating tank T-1.

In case P-1a is conveniently located, the suction from slop tank T-11 may be manifolded into suction of pump P-1a and this pump used.

(159-A) Standard W. I. pipe and fittings should be used with brass valves and double strainers equal to the product of the Elliot Manufacturing Company.

(160) All Valves and Cocks on Brine Lines Should be Iron.—

RUN-DOWN HEADERS.

(161) Wax-Free Oil Header.—A 4″ header should be run underneath centrifuges with 2″ risers to oil spouts on machines. This header must be run with a uniform grade, free from pockets and traps, to the run-down tank T-6. Cover with cork brine covering. Standard W. I. pipe and fittings with brass valves should be used.

(162) Wax-Water Header.—A 4″ header should be run underneath centrifuges with 2″ risers to the wax spouts on the machines. This header must be run with a uniform grade to tank T-8. The pipe is to extend 3″ below level of the wax overflow to seal the line. Baffle plate 1′ square should be provided 2″ below end of line to arrest the force of the flow. Galvanized iron pipe and fittings with brass valves should be used.

(163) Electrical Equipment.—(*a*) Motor for chilling tank agitators. One 10 H. P. slow-speed squirrel cage motor with starter. Switch should be installed near pumps P-3, P-4, and P-5.

(*b*) Specifications covering the electrical equipment and wiring in connection with the centrifuges accompany the machine.

(*c*) We recommend as a matter of safety that all panels containing fuse plugs be placed outside of building and that all open switches inside of building be of the oil type.

(*d*) All lamps inside of building should be gas proof and should be equipped with wire guards. All wiring should be in conduit.

(164) Refinery Equipment.—(*a*) In addition to the foregoing process equipment, sufficient storage facilities must be provided for the filtered stock, naphtha, dilute wax-free oil, and dilute wax. Also the reduced wax-free oil and petrolatum.

(*b*) Sufficient filter capacity must be provided to filter the diluted stock. If the crude is of asphaltic or mixed base, adequate facilities for acid treating must be provided.

(*c*) Sufficient still capacity must be provided to reduce the wax-free oil and the wax to recover the naphtha.

DESCRIPTION OF PROCESS.

The following is a brief description of the manner in which The Sharples Process is operated, both for the manufacture of bright stock and for the dewaxing of long residuums.

Pretreatment of Oil.—No matter whether the stock is a *cylinder stock* or a *long residuum,* it is necessary that it be brought to color before dewaxing. If the stock is from a mixed base crude it should be acid treated and filtered. If it is from a straight paraffin base crude it should be filtered to color.

Before chilling the stock is diluted with naphtha. Where bright stock is manufactured the dilution is from 50 per cent to 60 per cent naphtha and from 40 per cent to 50 per cent stock. Where long residuums are dewaxed the dilution is on the basis of from 60 per cent to 65 per cent naphtha and from 35 per cent to 40 per cent stock. The gravity of the naphtha should be approximately 57° Bé. at 60° F. or lighter. It should be straight cut with an end point not higher than 420° F. The material so prepared is then passed to The Sharples Process.

Operation of Process.—Refer to process diagram (see Fig. 4). The dilute stock is heated in tank T-1 and agitated to insure complete solution. In heating it is necessary that it be brought up to a temperature at which it appears to be brilliant. The temperature to which the stock is heated will vary from 100 to 110, depending upon the nature of the crude from which the stock is made. The dilute stock is then chilled alternately in tanks T-2, T-3 and T-4. The chilling is carried on gradually through a period of 48 hours until the oil has been reduced in temperature to –10° F. The chilled oil is then passed continuously through a battery of Sharples Super Centrifuges. The centrifuges separate the wax from the oil. The wax-free oil is continuously discharged from one point while the wax is discharged from another.

The Chilling System.—Brine is used as a chilling medium. The main circulation of brine is pumped from tank T-10 by pump P-2, thence through the brine cooler. The brine is discharged from the brine cooler at a temperature of –20°.

As has been previously said, the oil is chilled alternately through a period of 48 hours from mixing temperature to –10 in tanks T-2, T-3 and T-4. At the same time it has been found advisable to reduce the temperature of the brine in the chilling coils of each chilling tank at the same rate at which the temperature of the oil is reduced, never allowing the temperature of the brine to become more than 10° lower in temperature than the required temperature of the oil at any given time in the chilling period.

From the above it is seen that it is necessary that the temperature of the brine in the chilling coils of the various tanks will vary considerably and will require separate control.

Chilling Control.—The temperature of the chilling brine in each chilling tank is controlled as follows: Individual pumps such as pumps P-3, P-4 and P-5 are connected with the brine coils in each chilling tank. The suction side of each of these pumps is connected with the main circulation of –20 brine by means of a needle valve as well as with one end of the pipe leading to the coil of the tank with which the pump is connected. The discharge of the pump leads to the other end of the chilling coil. The pump increases the velocity of the brine circulation. The needle valve is adjusted so as to allow just enough cold brine to enter the chilling coils so as to bring the temperature of the brine down at the desired rate. The excess brine in the chilling coils is given off at the relief valves. The warm brine thus discharged is passed through the wax-free oil recovery coil C-1 in tank T-6, where the refrigeration from the wax-free oil is reclaimed. Once the needle valve has been adjusted the operation is practically automatic. For a given quantity of oil an equal volume of cold brine would be required in each repetition of the operation. The chilling is thus completed at the rate of 2½° per hour.

The Chilling Tanks.—Each chilling tank is sufficient in capacity to supply the centrifugals installed with dilute oil for a period of 24 hours. Each tank is equipped with an agitator to prevent settling. The sequence of their operation may be illustrated as follows.

Assume that the oil in chilling tank T-4 has been properly chilled and is ready for centrifuging. At the same time, the oil in chilling tank T-3 would have completed 24 hours of the 48-hour chilling period whereas tank T-2 would have been filled with warm oil. While the contents of tank T-4 are being centrifuged through a period of 24 hours, the contents of tank T-3 would be passing through the second 24 hours of the 48-hour chilling period and the contents of tank T-2 through the first 24 hours of the 48-hour chilling period. As soon as the contents of tank T-4 have been run, the temperature of the oil in tank T-3 would have reached centrifuging temperature and the centrifuges would continue to operate on the contents of this tank. In the meantime, warm oil would be pumped to tank T-4 in order that the chilling cycle could be started there whereas the contents of tank T-2 would be entering upon the second 24 hours of the 48-hour chilling period. Thus the operation would continue in such a way that the centrifuges would be continuously supplied with chilled oil and the oil continuously chilled, first in one tank and then the next through the desired period of time, to the desired centrifuging temperature and at the required rate of chilling.

The Wax Separation.—When the oil has finally reached centrifuging temperature it either flows by gravity from the chilling tanks to constant level tank T-5 equipped with float valve, or in the case of an installation where chilling tanks are not elevated, it is transferred by pump from chilling tanks to elevated tank T-12 which takes the place of tank T-5. From this tank the oil flows by gravity to the Super Centrifuges such as 1, 2, 3, 4, etc. from a constant head. The commercial process chart shows elevated chilling tanks. Our estimates, however, contemplate ground tank installations.

The essential feature of the centrifugal separation of the wax from the lubricating oil is the continuous discharge of the wax from the machines. For this purpose a special rotor has been constructed. Hot water at a temperature of about 140° F. termed "carrier liquid" is fed by jets into the head of the machine. The carrier liquid being heavier than the wax or the oil

maintains itself as a flexible carrier in the form of a cylindrical layer on the periphery of the rotor of the machine. *The stiff wax is deposited upon the surface of the water and the wax is conveyed from the machine by it.* In other words, it insures a complete and continuous separation of the wax from the oil, making possible the production of a stiff (oil-free) wax. In addition, by utilizing hot water as a carrier liquid, the wax is melted as rapidly as it is discharged from the machines that it may flow by gravity to the wax run-down separator tank T-8 where the water and wax are separated by gravity. The water flows automatically to tank T-9 from which tank it is pumped back through the system and reused. The dehydrated wax flows to tank T-7 from which it is pumped to storage or for reduction.

Wax-Free Oil Discharge.—The wax-free oil leaves the centrifuges at a temperature of –5° F. It is then passed through the exchanger coil in tank T-6 in order to recover its refrigeration, after which it is reduced.

(165) Heating System for Pump House, Receiver House, Etc.—(For calculation of square feet of radiation see Section 217.)

Pipe coils are to be made of standard 1¼″ wrot-iron pipe (standard threads at both ends).

Couplings (where necesasry) must be recessed line pipe couplings.

Screwed fittings should predominate and should be standard C. I.

Unions are to be standard C. I. screwed-end having brass to iron seats.

C. I. hook plate supports are to support the pipe coils, and lagged to spruce wood blocks with 3″ long wooden screws. Pipe must be at least 1½″ away from wall and should slope 1″ per 20 feet toward the return end in order to secure the proper drainage.

Each coil should be provided with a 1¼″ Webster[1] modulation valve located on the steam supply, near each coil, and a 1¼″ Webster[1] water-seal motor attached to the return or discharge end of the coil.

[1] Warren Webster & Company.

Traps are to be (state size desired) low pressure steam traps suitable for 10 to 30 pounds steam working pressure equal to the Strong, Carlisle & Hammond traps.

Back pressure valve is to be of the noiseless, double-disc, piston type, iron body bronze-mounted for vertical position and equipped with water seal and cushioning device. It is to be set for a steam working pressure of 5 pounds and to be equal to Crane No. 417. The flanges are to be faced and drilled to the A. S. M. 125 lb. standard dimensions.

Reducing valves (are used to by-pass live steam into heating system in case no exhaust steam is available) will reduce and maintain automatically a constant pressure. Where low pressures of from 0 to 25 pounds per square inch is employed a Mason[1] lever type reducing valve or its equal is recommended. The size of the reducing valve is often made twice the size of inlet thus increasing the area four times.

The exhaust head should be of galvanized sheet iron (state size of exhaust pipe), sizes 1″ to 4½″ should have screwed connections, above 4½″ should have the flanges faced and drilled to A. S. M. E. 125 lb. standard dimensions. The construction is to be equal in all respects to the Crane exhaust head as shown in Catalogue No. 50, page 543, and is to be shipped crated.

(166) Reinforced Concrete Oil Separator (to Recover all Waste Oils).—The separator is of a rectangular form (no roof necessary) having a series of baffle walls and skimming pipes conforming to the dimensions shown upon the drawing. The separator must be so designed that the velocity of its contents will not exceed from 1 to 1½ feet per minute. Monolithic construction is desired and recommended.

The concrete mixture should be:

One part of Portland cement,

One and one-half parts clean, sharp sand, free from dirt or loam,

Three parts well graded crushed stone or pebbles not larger than one inch.

[1] Mason Regulator Company.

The reinforcing rods should be plain or deformed round bars, conforming to specifications of A. S. T. M. billet steel construction reinforcement structural grade.

The skimming pipe (or pump suction) is to be standard black merchant pipe.

One and one-fourth inch diameter pipe railing should completely enclose the entire separator. The pipe is to be pin connected at posts, which are to be spaced not more than 6 feet apart and made of 1¼″ diameter pipe and standard malleable screwed fittings. The floor flange of each post must be securely anchored with proper expansion bolts properly expanded in the concrete walls.

After completion, the entire railing is to be given two coats of black graphite paint.

Curing of the tank is necessary, hence, one of the two methods given below, that have been successfully used, may be applied.

Method 1.—About 24 hours after all concrete has been placed, fill the separator with clean water for about one month.

Method 2.[1]—The floor and interior walls should be coated with silicate of soda. For this purpose, use three or four coats of 1 to 4 solution of 40° Bé., sodium silicate, followed by a finish coat of a 1 to 2 solution. This forms a glazed coat on the concrete, but does not last more than a year, and when its purpose of allowing the concrete to harden has been fulfilled its presence is no longer required. The concrete should be allowed to harden and age for one month before using the separator, as this increases the oil tightness of same.

(167) Sewers.—Practical experience points out that two systems of sewers are essential, one sewer for sewage or sanitary purposes, and one combined sewer for storm water and waste oil. The latter is to be conducted to the main water and oil separator (see Section 166). The flow of sewage in sewers is generally calculated as:

2 feet per second the minimum velocity.

15 feet per second the maximum velocity.

[1] The second curing process is usually used when water is not available for curing purposes.

All sewers up to 30″ are to be of standard No. 1 quality vitrified salt glazed clay pipe and fittings. The pipe is to be laid as specified in Section 57.

All sewers above 30″ are to be of reinforced concrete construction.

The mixture is to be as follows:

One part Portland cement,

Two parts clean, sharp sand free from dirt or loam,

Three parts well graded coarse stone or gravel to pass 1″ ϕ ring.

The steel reinforcing rods (that are necessary) are to be plain or deformed and must conform to the latest specifications of the A. S. T. M. billet steel.

APPROXIMATE WEIGHTS AND DIMENSIONS OF STANDARD QUALITY VITRIFIED SALT GLAZED SEWER PIPE.

Calibre	Weight per foot	Depth of socket	Annular space	Thickness
3 in.	7 lbs.	1½ in.	¼ in.	½ in.
4 "	9 "	1⅝ "	⅜ "	½ "
5 "	12 "	1¾ "	⅜ "	⅝ "
6 "	15 "	1⅞ "	⅜ "	⅝ "
8 "	23 "	2 "	⅜ "	¾ "
9 "	28 "	2 "	⅜ "	13/16 "
10 "	35 "	2⅛ "	⅜ "	⅞ "
12 "	45 "	2¼ "	½ "	1 "
15 "	60 "	2½ "	½ "	1⅛ "
18 "	85 "	2¾ "	½ "	1¼ "
20 "	100 "	3 "	½ "	1⅜ "
22 "	130 "	3 "	½ "	1⅝ "
24 "	140 "	3¼ "	½ "	1⅝ "
27 "	224 "	4 "	¾ "	2 "
30 "	252 "	4 "	¾ "	2⅛ "
33 "	310 "	5 "	1¼ "	2¼ "
36 "	350 "	5 "	1¼ "	2½ "

APPROXIMATE WEIGHTS AND DIMENSIONS OF EXTRA HEAVY QUALITY VITRIFIED SALT GLAZED SEWER PIPE.

Calibre	Weight per foot	Depth of socket	Annular space	Thickness
15 in.	75 lbs.	2½ in.	½ in.	1¼ in.
18 "	118 "	2¾ "	½ "	1½ "
20 "	138 "	3 "	½ "	1⅔ "
22 "	157 "	3 "	½ "	1⅚ "
24 "	190 "	3¼ "	½ "	2 "
27 "	265 "	4 "	¾ "	2¼ "
30 "	290 "	4 "	¾ "	2½ "
33 "	335 "	5 "	1¼ "	2⅝ "
36 "	375 "	5 "	1¼ "	2¾ "

Minimum carload = 24,000 lbs.

(168) Specifications for Oil Compounding Kettles (Steam or Oil Jacketed).—The kettle, jacket, inner shell and reinforcing connections or, "Stay Bolts" between inner and outer walls are all to be cast in one piece from one ladle of iron. The walls should be thin to insure a rapid heating and cooling effect; the design of the kettle and the placing of the "Stay Bolts" are to be such that the complete kettle will be tight at 150 pounds per square inch hydrostatic pressure test.

Material is to be highest grade cast iron, extremely close-grained, being ductile and having tensile strength of 35,000 to 40,000 pounds per square inch and machining sharp and clean.

Molds and cores must be highly treated to insure perfectly smooth casting from the mold itself, as grinding to obtain smoothness destroys the outside skin of a kettle which is so valuable to a compounding kettle in increasing its life.

The iron analysis should be as follows: Silicon 2.85 to 3.00; sulphur 0.12 to 0.14; phosphorus 0.16 to 0.18; manganese 0.50 to 0.55; total carbon 3.25 to 3.50.

Great care must be used in carefully cooling down the kettle after it is poured to insure a perfectly balanced casting.

(169) Type of Building Construction Recommended for Various Refinery Departments.—The receiving house, filter and burner house, transfer and loading pump house, wax plant, compounding and barreling plant, and boiler house are all to be of masonary or reinforced concrete and steel construction throughout. All exposed steel work is to be fire-proofed with either concrete, terre cotta or gypsum blocks. All floors and roofs are to be of non-combustible construction. Only metal window frames, sashes, doors and wire inserted glass should be used.

The power house, machine shop, carpenter shop, locker and lunch room, pipe shop, car repair shop, steel fabricating shop, electrical shop, barrel and can manufacturing plant, storage sheds, and office building, all are to be of masonary or reinforced concrete construction. The exposed steel work need not be fire-proofed. Roof is to be of non-combustible construction. Floors and other interior work may be wholly or partly constructed of wood. Metal window frames, sashes, doors, wire inserted glass

or polished plain glass may be used depending upon local conditions and fire zone.

The temporary buildings, or buildings not exposed to fire hazards may be of frame construction throughout with walls, partitions and roof of wood or corrugated steel metal.

For building and roof truss designing data (see Section 169-A).

(169-A) In making a design for a building the span of the roof is generally given, also certain limits regarding its height and style.

The following are the steps of procedure.

(a) Design the roof covering and find its weight.
(b) Make skeleton outline of the proposed truss.
(c) Assume proper snow and wind loads.
(d) Compute maximum stresses in all members.
(e) Assume proper working unit stresses for the materials.
(f) Design the sections of the connections.
(g) Make drawings, compute weights and estimate cost.

NOTE:—Always calculate the weights of truss after designed and check up with the approximate weight of assumed weight and if the difference is as great as 10 per cent it would be advisable to *redesign* the *stress* calculation.

BRACING.

The transverse bracing consists of knee-braces, connecting *trusses* and *columns*, see Fig. 9.

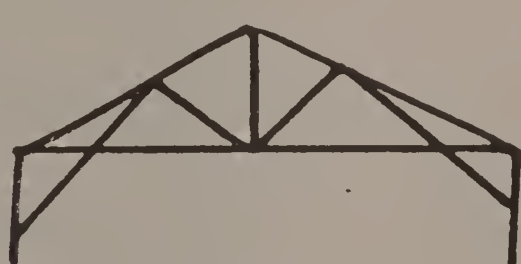


Fig. 9.

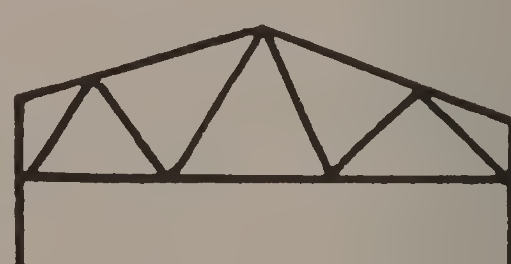


Fig. 10.

No knee-braces are required in *trusses* as shown in Fig. 10.

Longitudinal bracing may be put in-3-planes as that in the plane of rafters which is called a *rafter-bracing.*

The *bracing* in the plane of the bottom chord is called the bottom chord bracing.

The bracing in the vertical planes between columns is called side bracing.

One panel of longitudinal bracing is necessary to take care of the longitudinal (wind pressure) forces, but for convenience in erecting the steel work, not less than two panels are braced in long buildings, the braced panels are not spaced farther apart than three or four panels.

WEIGHT OF ROOF TRUSSES.

(Steel and Wood Trusses).

NOTE: The weight of roof trusses are generally assumed and are not actually known until each member is computed to sustain their respective loads. Therefore, the first computation must include the dead weight of the roof truss, and after the proper members are determined in the truss its actual weight must be compared with the assumed weight to see if the proper allowance is sufficient.

The weight of roof trusses may be determined approximately by the following formula:

W = approximate weight of roof truss in pounds.
X = 0.50 for wood, 0.75 for iron or steel.
C = center to center of roof trusses in feet.
L = span of roof truss in feet.
Hence:

$$W = X\,C\,L\left(1 + \frac{L}{10}\right).$$

(170) Extinguishing Oil Fires.—There are two principal methods of extinguishing burning liquids, as follows: To form a blanket of gas or solid material over the burning liquid and so cut off the air (oxygen) supply; and to dilute the burning liquid with a non-inflammable extinguishing agent that will mix with it.

Water may be used if the burning liquid is miscible with it. Such miscible liquids include denatured alcohol, wood alcohol, and acetone. When the liquid, like gasoline, is not miscible with water, little or no effect is produced by using water, except to wash the burning liquid out of the building, and thus scatter the

fire over a large area. But in extinguishing a small amount of burning oil, a large quantity of water may aid by its cooling effect.

Of those materials used for extinguishing liquid fires by forming a blanket of gas or solid material over the burning liquid, thus cutting off the oxygen supply, several are in common use. These include sawdust, sand, carbon tetrachloride, and the so-called foamy or frothy mixtures.

Inasmuch as it is difficult to retain the blanket of gas over the burning oil, only the foamy mixture will be discussed in detail.

Equipment for using foam or frothy mixtures to extinguish fires in large gasoline storage plants originated in Germany. The process consists in causing two liquids to mix, whereupon foam is produced, which is forced out by pressure of carbon dioxide gas simultaneously generated, and acts as a blanket in excluding air (oxygen) from the fire. The foam is tough and shrinks only slightly in volume even after half an hour.

The foamy mixture may be composed by the following formula:

Solution No. 1	Solution No. 2
12 per cent aluminum sulphate	8½ per cent sodium bicarbonate
2½ per cent powdered extract licorice	91½ per cent water
85½ per cent water	

Each of the above solutions should be pumped in separate pipe lines and in equal quantities. The mixing of these solutions

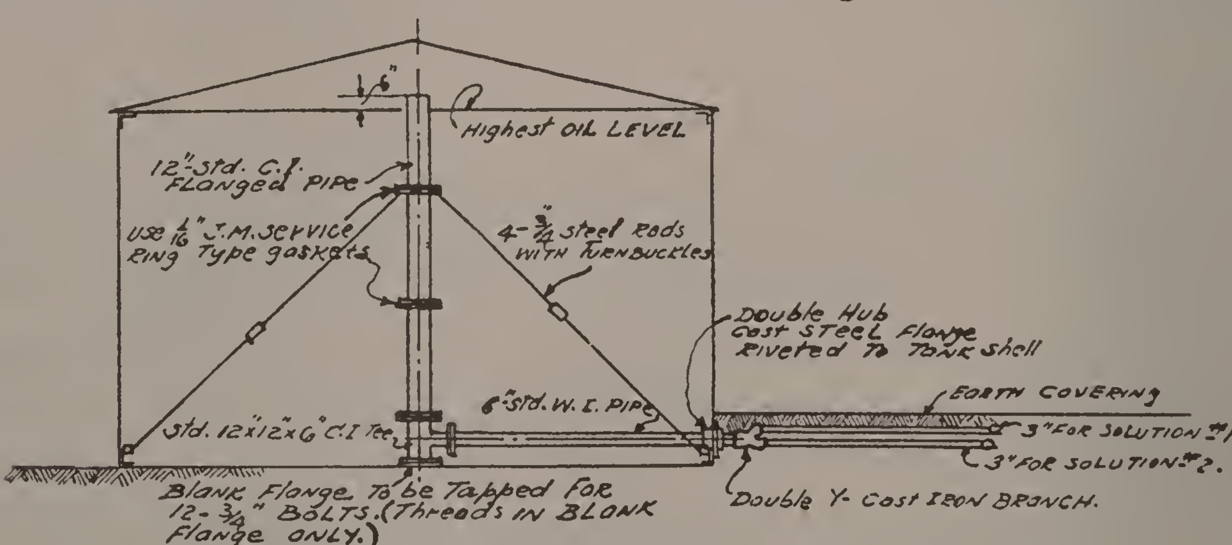


Fig. 11.

should occur only at the tank and it is very important to distribute it evenly throughout the burning area, without any delay. (See Fig. 11).

One gallon of mixed solution produces seven to nine gallons of foam and will cover 2 square feet of oil surface to a thickness of 8 inches.

The type of pump recommended is the double-acting duplex piston-pattern steam pump, which is the most reliable for intermittent or continuous service. The specifications of the pump to be as follows:

Fluid end for Solution No. 1	Bronze cylinders, liners forced into cylinders. Bronze pistons and piston rods.
Fluid end for Solution No. 2	To be all iron fitted.

Steam end is to be standard duplex design and designed for a steam working pressure. of (state pounds per square inch). The piston rods are to be made in one piece where the stroke is 6 inches or less, and when the stroke is over 10 inches it should be divided at the cross-head. Fibrous packing is to be used throughout.

For Solution No. 1. Only wrought iron pipe should be used. Flanged C. I. fittings. Iron body bronze mounted flanged gate valves. Lead lined steel storage tank should be used for solution storage.

For Solution No. 2. Only standard steel pipe should be used. Flanged C. I. fittings. Iron body iron mounted flanged gate valves. Steel storage tank should be used for solution storage.

Of the several methods employed to mix the solutions at the tank, the central pipe column is the one most commonly used. Above diagram illustrates foam mixing arrangement for tanks from 50 feet to 115 feet in diameter; size of foam lines must depend on length. Nominal sizes as shown are sufficient for mains approximating 2,500 feet in length.

(171) Specifications for Leather Belts (for Belt Driven Machinery or Conveyors).—A. Belting should be made only from No. 1 packer steer hides.

B. The hides should be tanned with oak bark by the slow tanning process.

C. The leather should be thoroughly cured with animal oils and greases, the use of artificial fillers or adulterants is absolutely prohibited.

D. The leather should be of uniform quality, thoroughly stretched while damp and dried under this tension. The grain side should have a smooth finish and be thoroughly fleshed.

E. All strips should be cut from the central part of the hide, (to include only firm stock) maximum width allowable is 15″ either side of the backbone, while the maximum allowable length is 48″.

F. The thickness for the various grades of belting should be in accordance with the following schedule:

	Single ply	Double ply
Light grade	0.125″ to 0.15625″	0.2344″ to 0.2656″
Medium grade	0.15625″ to 0.1875″	0.2969″ to 0.3281″
Heavy grade	0.1875″ to 0.21875″	0.3594″ to 0.3906″

G. The use of resin or mineral oil is absolutely prohibited.

H. All laps must run in the same direction and the lengths of the laps should be in accordance with the following schedule:

Single ply belts under 0.1562″ thick x 5″ wide laps are to be from 2½″ to 6″ long.

Single ply belts above 0.1562″ thick x 5″ wide laps are to be from 3″ to 8″ long.

Single ply belts under 0.1562″ thick and above 6″ wide laps are to be from 3″ to 8″ long.

Single ply belts above 0.1562″ thick and above 6″ wide laps are to be from 3½″ to 10″ long.

Double ply belts up to 0.2656″ thick x 5″ wide laps are to be from 2¼″ to 3½″ long.

Double ply belts above 0.2656″ thick x 5″ wide laps are to be from 3″ to 4″ long.

Double ply belts up to 0.2656″ x 6″ wide and over laps are to be from 3″ to 4″ long.

Double ply belts up to 0.2656″ thick x 6″ wide and over laps are to be from 3″ to 4″ long.

Double ply belts above 0.2656″ thick x 6″ wide and over laps are to be from 3″ to 5″ long.

I. All laps should be thoroughly cemented together and the cement recommended for the laps is to be equal in quality to the following formula and is to be applied warm.

Fifty per cent glue[1] and 50 per cent isinglass.—Soak in water for a period of 10 hours, then heat the ingredients and water to a boiling point and add pure tannin until mixture is of the desired consistency.

J. All belting should be properly marked (on the grain side) with the manufacturers' name and brand, and in which direction the belt is to run.

K. No cracks should be visible on the grain side and the laps should not open at their respective points when the belt is bent to 180 degrees around bars as specified below:

Single belts under 0.1562″ thick—1″ diameter bar.
Single belts above 0.1562″ thick—1¼″ diameter bar.
Double belts up to 0.2656″ thick—3″ diameter bar.
Double belts above 0.2969″ thick—4″ diameter bar.

L. No belt dressing should be used unless belt appears dry and then it is recommended to use sparingly a dressing composed of the following formula: 67 Per cent beef tallow and 33 per cent cod liver oil.

Tallow should be melted and allowed to cool until the finger can be inserted without burning—then add the cod liver oil and stir until cooled.

M. When the customer desires, the manufacturer should furnish a suitable sample of the belt offered with his proposal. The sample should show the texture, thickness and have at least one lap; it should not be treated with any belt dressing.

N. All inspections should take place at the point of manufacture.

O. The belting should be shipped in accordance with the instructions of the customer.

P. In conclusion, the manufacturer agrees that should the belt not be equal in quality to the approved sample (the customer reserves the right to inspect at point of delivery) and if the belting

[1] Use 1⅜ test glue having a viscosity of 25 at 180° F.

is rejected it must be removed by the manufacturer at his own expense.

Q. Any lacing that is desired should be only well balanced hand cut, lengthwise, from (No. 1 packer steer) green slaughter hides of the best quality, must not be chemically treated and should be free from cuts, grubs or any other imperfections.

(171-A) Belting Data.—*Arc of Contact*—All formulas generally presume a wrap of 180 degrees, or one-half the circumference of the pulley.

If the belt touches three-fourths of one-half the circumference of the pulley, it can transmit only three-fourths of the rated horsepower, or if, by use of a tightener, the belt is made to touch five-eighths of the whole circumference, one-fourth more power may be transmitted than a formula would allow.

Ratio of Friction.—The ratio of friction to pressure for belts over wood-pulleys is 0.47 for worn leather belts and 0.50 for new leather belts.

When leather belts are used over turned C. I. pulleys the ratio is 0.24 and 0.47 respectively.

SPECIFICATIONS FOR A 100-TON ABSORPTION REFRIGERATING MACHINE.

(See Fig. 5).

Contractor should furnish one absorption refrigerating machine; same to be in accordance with the following specifications:

(172) **Generator.**—Horizontal shell and coil type, one shell, 49″ diameter by 24′10″ long, made of ⅝″ flange steel, welded seams, steel flanges, cast air furnace iron heads, cast iron stands, headers, valves and fittings, each shell is to contain ten continuously welded coils made of 2″ extra heavy pipe, containing a total of 1,400 square feet of surface or 2,240 lineal feet.

(173) **Analyzer.**—Horizontal type, 30″ diameter by 14′ long, made of ½″ flange steel, welded seams, steel flanges, cast air furnace iron heads, cast iron stands, valves and fittings, shell is to contain twelve improved C. I. heat exchange trays.

(174) **Dehydrator.**—Double pipe type is to consist of six coils, four pipes high, 18′2″ long. Made of 2″ and 3″ ammonia pipe, complete with water distributing device, stands, headers, valves and fittings. Stands and a drip trap are made of cast close-grained air furnace iron.

(175) **Ammonia Condenser.**—Double pipe type is to consist of twelve coils, twelve pipes high, 19′ long. Made of 1¼″ and 2″ ammonia pipe, complete with water distributing device, stands, headers, valves and fittings. The pipe is to be screwed and sweated into return bends.

(176) **Exchanger.**—Double pipe type is to consist of four coils fourteen pipes high, 19′4″ long. Made of 2″ and 3″ ammonia pipe, complete with stands, headers, valves and fittings.

(177) **Weak Aqua Cooler.**—Double pipe type is to consist of two coils twelve pipes high, 19′ long. Made of 1¼″ and 2″ ammonia pipe, complete with stands, headers, valves and fittings.

(178) **Absorber.**—Double pipe type is to consist of ten coils twelve pipes high, 18′2″ long. Made of 2″ and 3″ ammonia pipe, complete with water distributing device, stands, headers, valves and fittings.

(179) Strong Aqua Ammonia Tank.—One horizontal strong aqua tank 24″ diameter, 10′ long, provided with cast iron stands, valves, fittings and liquid level gauge. Tank is to be made of flange steel with welded shell and heads and is to be tested and proven tight at 500 pounds hydraulic pressure or 300 pounds air pressure per square inch. The gauge glass is to be annealed Scotch glass complete with guards.

(180) Ammonia Receiver.—One horizontal ammonia receiver 24″ diameter, 10′ long, provided with cast iron stands, valves, fittings and liquid level gauge. Tank is to be similar to strong aqua ammonia tank. (See Section 179). The gauge glass is to be annealed Scotch glass complete with guards.

(181) Dehydrator Drip Trap.—One standard high pressure trap, size 12″ x 36″ complete with gauge glass, valves and fittings.

(182) Aqua Ammonia Pump.—One steam-driven simplex double-acting ammonia pump, capable of handling aqua ammonia of any strength, steam cylinder 16″ diameter, ammonia cylinder 8″ diameter, stroke 10½″. Pump is to be complete with cast iron base plate and drip pan, lubricator, valves, fittings and automatic regulating device. Piston rods are to be made in two sections of nickel steel. The steam cylinder and cross-head barrel are to be cast in one piece of close-grained air furnace iron, designed for a working pressure of 250 pounds.

(183) Gauge Board.—One ornamental cast iron gauge board to contain the following 8″ gauges: one boiler steam, one generator steam, one generator ammonia, one absorber, one brine cooler system, all gauges are to be plainly lettered to indicate their service.

(184) Ammonia Connections.—All necessary interconnections for ammonia between the generator, analyzer, dehydrator, high pressure trap, ammonia condenser, receiver, exchanger, weak aqua cooler, absorber, ammonia pump, gauge board and evaporating system.

(185) Steam and Exhaust Connections.—Contractor should furnish all necessary steam and exhaust piping, valves and fittings within the machine room for connecting to the purchaser's steam

and exhaust mains all of the machinery and apparatus covered by these specifications.

(186) Water and Drain Connections.—Contractor should furnish for supplying to and draining from all of the machinery and apparatus covered by these specifications, all of the piping, valves and fittings necessary within the rooms where such machinery and apparatus are located, to connect the same with purchaser's water supply and drain mains.

(187) Brine Cooler.—Shell and tube type, 46″ diameter, 14′6½″ long, made of ⅜″ flange, steel, welded seams, steel flanges, cast iron heads, cast iron stands, headers, valves and fittings, brine chambers divided into eight passes. Shell is to contain one hundred and sixty 2½″ wrought iron boiler tubes, the same to have a total of 1,500 square feet of effective surface. Brine cooler is to be tested to 200 pounds water and air pressure on the ammonia side, and to 100 pounds on the brine side.

(188) Insulation of Generator and Analyzer.—Contractor should furnish insulating material for covering the generator and analyzer with (not less than 2″) high pressure cement held in place with iron bands, the whole covered with 8-ounce duck and given two coats of lead and oil paint.

(189) Insulation of Brine Cooler.—Contractor should furnish insulating material for covering brine cooler with (not less than 6″) cork board lags, held in place with iron bands, and given two coats of heavy water-proof insulating paint.

(190) Pans.—Contractor should furnish suitable water tight pans with needed drains. These pans can be made of $^3/_{16}$″ black steel with welded seams. In case sea water or water containing sulphur is used for cooling purposes, the pans should be made of ¼″ black steel, with welded seams.

(191) Ammonia Charge.—Contractor should furnish sufficient aqua ammonia to test 29° Bé. at 60° F., also sufficient anhydrous ammonia and charge system with same, both to be subject to the approval of the client as to quality.

(192) Testing Set.—Contractor should furnish a leather case, containing one hydrometer for salt, one hydrometer for ammonia, one glass brine testing jar, one ammonia testing bottle with

graduated scale, one chemical thermometer graduated from minus 30° F. to plus 30° F., and one chemical thermometer graduated from 0° F. to plus 300° F.

(193) Guarantee.—Contractor guarantees the above specified refrigerating machine under test will have capacity to cool 500 gallons of brine per minute of a specific gravity of 1.25 through a range of 5° F. with outlet temperature 0° F. when properly operated and kept free from air and gases other than those of the vapor of water and ammonia, and the aqua ammonia kept at the strength prescribed above, and in the performance of this work will use not to exceed 35 pounds of dry steam in the generator per ton of refrigeration per hour per day, at 5 pounds pressure, with cooling water at a temperature of 60° F.

(193-A) Accurate Equation for Figuring Refrigeration Tonnage.—

$$\frac{P \times S \times (t - t_1)}{288{,}000} = \text{Tons refrigeration in 24 hours.}$$

P = Pounds of substance cooled.
S = Specific heat.
t = Temperature of substance to be cooled.
t_1 = Temperature of substance after cooling.
288,000 = B. t. u. extracted in 24 hours per ton refrigeration.

Should the substance be cooled to a temperature at which it will congeal, the latent heat of fusion must be added to the above, the equation being as follows:

$$\frac{P \times L}{288{,}000} = \text{Refrigeration in 24 hours required to take care of latent heat.}$$

The value L differs with the character of the substance cooled.

For instance, if it is desired to cool and freeze 100,000 pounds of water per day from 90 to 15° F., we would have the following: The specific heat of water above freezing point being 1 and below freezing point 0.5, while the latent heat of fusion is 144 B. t. u. per pound.

		Tons refg.
To cool water to freezing point =	$\frac{100{,}000 \times 1 \times (90 - 32)}{288{,}000}$	= 20.14
To cool water below freezing point =	$\frac{100{,}000 \times 0.5 \times (32 - 15)}{288{,}000}$	= 2.95
Latent heat =	$\frac{100{,}000 \times 144}{288{,}000}$	= 50.00
		73.09
Add 15 per cent for radiation losses, etc.		10.96
Total tons		84.05

In arriving at the tonnage required to cool oil you should proceed along the same lines as above, the only difference being that the values for specific and latent heats would change.

In cooling brine, the latent heat need not be taken into consideration, as brine used in a refrigerating machine is made to a density at which it will not freeze, under the conditions at which the refrigerating machine is operating.

Very often the brine tonnage is figured on a gallon degree basis; that is, the cooling of one gallon of brine 25° F. or 25° gallon of brine 1° F. being equivalent to one ton refrigeration. For example, assume that we cool 500 gallons of brine per minute through a range of 5° F., we have $\frac{500 \times 5}{25} = 100$ tons refrigeration.

(194) Wax Packing and Moulding Machines.—The refined or semi-refined wax after being filtered is either packed in barrels in scale form or made into moulds for the market.

The wax is melted by means of steam coils in a receiving tank and by gravity is allowed to flow to a wax cooling and barreling machine.

This machine consists of a shallow pan containing the melted wax through which revolves a cast iron cylinder at a speed of about twenty-four revolutions per minute.

The cylinder varies in size and usually is 24 inches or 36 inches in diameter and 4 or 5 feet long. Cold water is circulated through the cylinder and the wax congeals or adheres to the surface.

It is scraped off by means of a suitable scraper or knife. The ribbon or film of wax falls to a single or double hopper into the barrels below.

A wax packer is sometimes used so as to get the maximum quantity of wax in each barrel.

The cylinder is revolved or driven by a chain from a counter-shaft which in turn is driven by a 5 H. P. motor with proper reduction gear. Shafting may be avoided by using bevel gears direct connected to back geared motor.

A wax moulding press may be used to form cakes weighing either 10¼ pounds or the smaller ¼ pound cakes known to the trade as "Parowax."

Insulation for Chilling Machine and Press Rooms.

It is not always necessary to insulate rooms containing chilling machines and presses.

The chilling machines themselves, are insulated with cork or hair felt and are bored in, using granulated cork, leaving the tell-tale cuds and outboard bearings exposed.

The ceilings of all press vaults should be insulated with sheet cork and sometimes the outside exposed walls. The usual practice is to have the outside walls arranged with an air space of say 2 inches between two 8-inch brick walls.

(195) Wax Sweating Pans.—Although the separation of soft or slack wax from paraffin distillate takes place in filter presses, it is to carry this operation further to remove the oil and moisture still contained in the soft wax so to have as near a freedom from oil as possible.

This is accomplished through the sweating process. This recrystallized wax is melted and pumped into a series of sweating pans which are enclosed in a chamber or vault, the pans placed over one another. These pans are arranged on a specially designed structural steel support.

By means of cold water pumped under the screens and through a series of ¾-inch coils over the screens, the melted soft wax to the depth of 4 to 6 inches is solidified over the screens. The water is then run off from the pans.

The room or vault is provided with steam coils on the side walls. This room is heated gradually to the temperature of the melting point or thereabouts which the wax is required to have. The warm water is then turned into the coils and the wax heated. An uneven temperature must be avoided and an automatic control in the form of a thermostat may be used. The coil and low melting paraffin will have dripped out the wax through the screens down into bottom of pans and then by run-down pipes to receiving tanks under the pans.

The remaining wax will then have become honeycombed and will have a given melting point. It is sometimes desirable to resweat this wax so as to have the desired finished melting point from 124° to 130° F.

The pans are of different sizes, made of ¼-inch steel riveted, the smaller being 16 feet long by 7 feet wide and 7 to 10 inches deep. The larger pans are 40 feet long by 10 feet wide and 10 to 12 inches deep. There are usually six or eight in each chamber or vault, all of which depends on the capacity of the plant.

The screen is made of 4-mesh galvanized iron or brass screen securely fastened by angle irons around the sides of the pans and must be perfectly tight and level.

The coils in the pans and directly over the screens are arranged for either cold or hot water, and, in addition, there are steam melting down coils.

There are draw-off connections from the bottom of the pans and at the center of the pans, so that the cold water, the oil and low melting point paraffin, and finely the melted sweated wax can be drawn off to properly arranged run-down tanks.

The temperature of the circulating water, the temperature of the sweating vaults govern largely the results obtained from the crude scale wax.

The building (to be constructed as per Section 169) for these pans should be either of brick or concrete and usually there is at least 4 feet clearance around the four sides of the tier of pans. With large doors at each end of the vault, so that the vaults may be cooled off quickly. All openings should be made as tight as possible during the sweating operation. The building itself must

be so located in the refinery that it may at all times receive an unobstructed circulation of air.

(196) **Chilling Machine.**—The double pipe distillate chilling machine is the counter current type. It is approximately 40 feet overall and consists usually of twelve sections, six pipes high and two wide.

The inner pipe is 6-inch full weight steel pipe in one piece and tested to 1,000 pounds per square inch. In this pipe is a steel helicoid conveyor, the helicoid wound on a double extra heavy pipe, and running at eight revolutions per minute.

The jacket pipe for the brine is a continuous 8-inch steel pipe, the brine circulation from the refrigerating machine passing through the annular space.

All fittings are cast iron extra heavy, both oil and brine being either of the return bend type or special tee construction for the distillate.

The conveyor shafts in inner pipes are extended through the ends of the machine, one end having cast iron driving sprockets. The conveyor driving ends are supported by heavy outboard bearings bolted to a rigid channel iron frame with a suitable take-up.

Each machine has three sets of structural steel channel iron supports.

The machine is driven by means of heavy link belt chain, engaging with 12-inch sprocket wheels, keyed and set screwed to the shaft.

The speed of the machine is controlled by means of speed reduction gear of the worm, spur, or bevel gear type, enclosed in proper housing and provided with tight and loose pulleys.

This machine may be driven from a countershaft or from a properly designed motor with back gear.

(197) **Filter Press.**—The horizontal hydraulic ended filter press is designed to separate soft or slack wax from paraffin distillate.

It consists of a frame built up with two cast iron platens and held by eight 3-inch tension rods. There are two side rods upon which rest the filter press plates, cotton duck filtering blankets

and spacing rings. The cotton duck used is known as 12/0 and weighs 3.07 pounds per square yard.

The press is set up by means of a cast iron cylinder or ram. The piston in this cylinder is coupled to a movable platen, and is made of cast iron, as well as the rod. Instead of ordinary piston rings, two chrome cup leathers are used. These leathers are held in place by two cast iron rings securely bolted. Access to the leathers is obtainable from the rear cylinder head.

The movable platen is actuated by the motion of the ram, so that the press can be closed under a pressure of 800 pounds per square inch, after which the press is locked during filtration by means of eight steel tension rods.

The press is provided with a four-way actuating valve, controlling the motion of the ram. The valve is made of bronze, the bonnet being fastened with four or six tap bolts to the valve body with a paper gasket between them.

The frame of the press has supports under the cylinder, also platens, side and tension rods, all supports are made of cast iron.

The stroke of the cylinder varies from 6 feet to 10 feet, depending upon the number of plates or, rather, the plate space. The maximum number of plates in each press is five hundred.

Under the press is a steel movable trough, supported on cast iron saddles with suitable rollers.

After filtration, this trough is moved to one side, so as to allow the soft wax to fall below to a helicoid screw conveyor made of steel. This soft wax is conveyed into a seeding tank made of ¼-inch steel.

The tank is provided with steam heating coils for melting the wax. A flat coil is made up of 2-inch black merchant pipe on 10-inch centers covering the bottom of the receiving tank. This coil is built up with standard C. I. elbows and sets on 4-inch by 4-inch spruce supports. Steam from the general refining system is used, care being taken not to overheat the desired melted wax.

The plates are made of steel, the center plate provided with lugs for supporting two side rods. The center plate of $^3/_{16}$-inch steel is assembled to two perforated or drainage plates over which are fastened suitable cotton duck filter press blankets.

The rings contain the soft wax and are made of steel ½ inch thick.

(198) Specifications for Drainage Piping and Fittings.—The metal used in the manufacture of drainage pipe and fittings should be extremely close-grained and ductile. It should have an ultimate tensile strength of not less than 20,000 pounds per square inch, and must permit easy cutting with file or diamond point chisel.

The iron analysis should be as follows: (no inferior admixtures are permissible).

Silicon	1.85 minimum
Sulphur	0.11 maximum
Phosphorus	1.10 maximum
Manganese	0.40 average

Before applying any coating on any pipe or fittings they must be tested to a hydrostatic pressure of at least 50 pounds per square inch, and any defective material should be rejected. All the material must be sound and free from cracks, sand holes and blow holes.

The filling of any cracks, etc., with any foreign substance should be absolutely prohibited. There should appear on all castings the manufacturer's name or initials, also the minimum or estimated weight, which marked weight in no case should be greater than the actual weight of the casting so marked, except that individual pieces may vary 5 per cent below the marked weight, providing the average weight of ten similar pieces selected at random are not less than the marked weight.

When drainage pipe or fittings are to be coated, the coating should be a coal tar pitch varnish, made from coal tar. This material must contain sufficient oil to make a smooth coating, tough, and tenacious when cold, and not brittle nor having any tendency to scale off or to be affected by abrasion. Each casting must be uniformly heated to 300° F., before being immersed in a uniformly heated coal tar pitch varnish bath at 300° F. and must remain in this bath for a period of two minutes.

The foot of all vertical drain pipe is to be permanently supported by suitable piers. The pipe under the basement floor to

be properly sloped and laid, and should be provided with ample supports to guard against settling.

Joints of drainage pipe, within building, should be made by caulking dry spun oakum tightly in hub annular space, leaving about 1 inch space in which to pour the molten lead, (to avoid trouble due to dampness place some pulverized resin in hub annular space before pouring lead) which must be caulked tightly after cooling. The lead that is used for the joints must be free from solder, or other metals and must always be poured hot.

Chart below (Fig. 12) illustrates the amount of oakum and lead that is required per each joint.

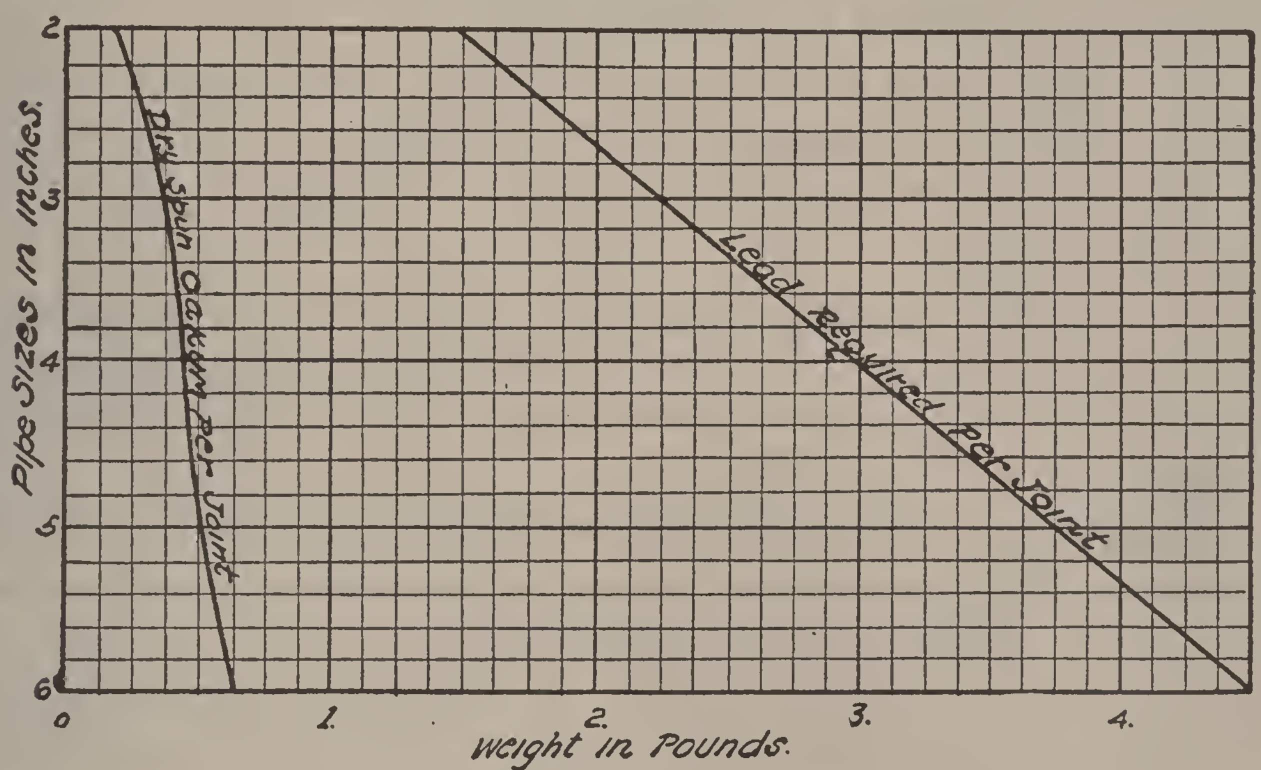


Fig. 12.

(198-A) Walk Ways.—All walk ways and stairs are to be 2′6″ wide.

A continuous walk way on top of stills the full length of battery should be provided.

A continuous walk way in rear of stills about 10 feet above the grade should be provided.

A continuous walk way on top of condensers should be provided.

A connecting cross walk way between top of stills and top of condensers should be provided.

Stair ways at each end of still battery and between condensers and rear of stills should be provided.

The treads and risers for stairs should be 10″ treads x 7½″ risers respectively.

The concrete footings should be of the following mixture:

One part Portland cement,

Three parts of clean, sharp sand,

Five parts of gravel, maximum size 2 inches.

All steel work is to be in accordance with A. S. T. M. standard specifications, A-9-21 structural steel for buildings. Workmanship should be in accordance with manufacturer's standard specifications, subject to customer's approval.

No connection is to have less than two rivets except where lacing is used (on columns or beams). All rivets are to be ⅝″ diameter except where noted otherwise. Open holes are to be $^{11}/_{16}$″ in diameter.

The columns supporting the walk ways are to be spaced not over 15′ centers and are to be provided with ample knee braces. The anchor bolts anchoring the columns need not be painted in shop.

Continuous double pipe (1¼″ diameter pipe) railing (total height of railing 42″) is to completely encircle the walk ways and stairs. Railing is to be pin connected at posts and may be bent at corners. Posts are to be 1¼″ diameter pipe, maximum spacing 6′ centers; fitted with X-heavy C. I. screwed fittings and bolted with ⅝″ diameter bolts to walk ways and stairs.

All steel work should be painted with one shop coat of red lead and oil and one field coat of an approved black graphite paint.

The walk ways and stair landings are to be Mitco[1] grating or its equal, stair treads are to be Mitco or its equal size 10″x2′6″. These should be painted with one field coat of an approved black graphite paint.

Pins connecting the railing to posts and all necessary ⅝″ bolts to anchor the railing posts must be furnished with railing.

[1] Mitchell-Tappen Company.

Railing contractor must furnish location holes for anchoring railing posts to steel fabricator for proper punching of holes.

Upon completion, the entire structure is to be given two field coats of an approved black graphite paint.

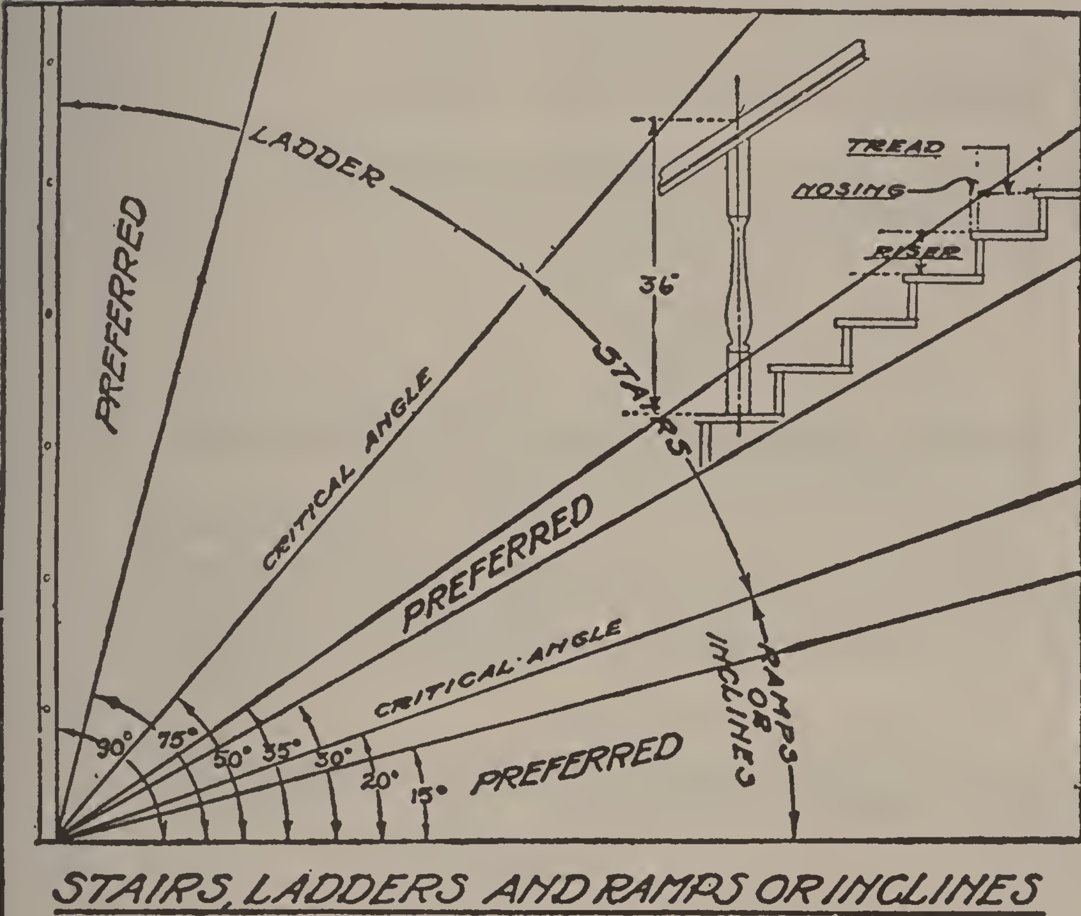


TABLE OF RISERS AND TREADS FOR STAIRS
(TREAD + RISER = $17\frac{1}{2}$")

ANGLE WITH HORIZONTAL	RISER IN INCHES	TREAD IN INCHES	
22°-00'	5	12½	
23°-14'	5¼	12¼	
24°-38'	5½	12	
26°-00'	5¾	11¾	
27°-33'	6	11½	
29°-03'	6¼	11¼	
30°-35'	6½	11	PFD.
32°-08	6¾	10¾	PFD.
33°-41'	7	10½	PFD.
35°-16'	7¼	10¼	PFD.
36°-52'	7½	10	
38°-29'	7¾	9¾	
40°-08'	8	9½	
41°-44'	8¼	9¼	
43°-22'	8½	9	
45°-00'	8¾	8¾	
46°-38'	9	8½	
48°-16'	9¼	8¼	
49°-54'	9½	8	

APPROVED STANDARD
WORKMENS COMPENSATION SERVICE BUREAU
SAFETY ENGINEERING DEPARTMENT

Fig. 12A. (Courtesy Amer-Abrasive Metals Co.)

(199) How to Determine the Steel Thickness for Horizontal Stills.—

$$W.\ P. = \left(\frac{2\ T\ t\ S}{D\ f}\right) \times \left\{100 - \left(0.05 \times \frac{t_1 - t_2}{1.8}\right)\right\}$$

(It is a known fact that the modulus of elasticity of steel diminishes in proportion with the rising temperature).

Hence:

W. P. = Safe working pressure pounds per square inch.

T = Ultimate tensile strength of plate pounds per square inch (usually 55,000 pounds per square inch.

t = Thickness of plate in inches.[1]

[1] Where there is a corrosive action because of the presence due to sulphur, or other contaminating constituents, in the crude oil which always attacks the metal only, above the liquid level. It is customary to increase the shell steel $^3/_{32}$" for each 5 years of service.

S = Efficiency of joint (welded or riveted type).
f = Factor of safety (5 is recommended).
D = Inside diameter of still in inches.
t_1 = Still contents temperature deg. F.
t_2 = Atmospheric temperature deg. F.

(200) How to Determine the Size of Vapor Lines.—

g = Total number of gallons of distillate per hour.
D = Diameter of vapor line in inches.

$$D = \sqrt{\frac{g \times 0.05}{0.7854}}$$

(201) How to Determine the Number and Size of Ventilators.—

Change of air required per person per hour for receiving house = 3,600 cu. ft.
Change of air required per person per hour for pump house = 3,600 cu. ft.
Change of air required per person per hour for work shops = 3,000 cu. ft.
Change of air required per person per hour for lavatories = 2,400 cu. ft.

CAPACITIES OF VENTILATORS.

(Assumed wind velocities 5 miles per hour and interior and exterior temperatures 60° F.)

Size of ventilator neck, inches	Capacity of ventilator, cu. ft. per hr.
12	16,500
14	22,200
16	29,400
18	39,000
20	48,000
24	66,000
30	102,000
36	153,000

(202) How to Determine the Proper Size of Condenser (Coils) Worms.—According to information published in *Mineral Oil and its By-products* by I. I. Redwood, the internal area of the cross-section of the condenser (coil) worm at the inlet to the condenser should be 0.05 square inch per gallon of distillate per hour and that this size should be continued for about one-third of the total length, then may be reduced by one-half inch for the next third and by another one-half inch for the last third.

According to the Scottish shale oil practice, there should be one square foot of condenser surface for each gallon of heavy

oil distilled per hour, 1¼ square feet for illuminating oil and 1¾ to 2 square feet for gasoline and naphtha.

(203) How to Determine the Amount of Water Necessary for Condenser or Coolers.—

$$W^1 = W \times \frac{S \times (t^1 - t^2) + L}{T^2 - T^1}$$

In which:

W^1 = Weight of water in pounds per hour.
W = Weight of distillate in pounds per hour.
S = Specific heat of distillate in B. t. u.
L = Latent heat of distillate in B. t. u.
t^1 = Temperature boiling point, distillate deg. F.
t^2 = Temperature distillate leaving condenser deg. F.
T^1 = Temperature water inlet, in condenser deg. F.
T^2 = Temperature water outlet off condenser deg. F.

(203-A) How to Compute the Capacity of a Crude Oil Distilling Unit.—

$$P = \frac{(d \times l \times 0.67) \times C}{42} \times 24 \times N,$$

$$d = \frac{1}{3}$$

In which:

d = Diameter of still in feet.
l = Length of still in feet.
N = Number of stills in the (battery) unit.
P = Capacity of distilling unit in barrels per (24 hours) day.

$$C = \begin{cases} 1.5 \text{ for coking or batch crude stills.} \\ 2.5 \text{ for continuous running crude stills.} \end{cases}$$

(204) How to Determine Size of Heat Exchangers.—To calculate the number of pounds of steam required to heat 100 pounds of oil per hour from 70° F. to 100° F. Steam is to be used at 15 pounds absolute pressure and assuming that there is 5° F. difference between the temperature of oil at outlet and the temperature of the condensed steam at outlet, consequently the temperature of water at outlet is 105° F. (5° F. is minimum for practice).

Hence: Heat given up by steam = Heat absorbed by oil.

Heat absorbed by oil = $W_2 \times S \times (t_2 - t_1) =$

$100 \times 0.498 \times (100\text{-}70) = 1494$ B. t. u. per hr.

Temperature of steam at 15 pounds absolute pressure = 250.3° F.

Latent heat @ pressure 15 pounds absolute pressure = 945.1 B. t. u.

Heat given up by 1 pound of steam = $W_1 \times S_1 \times (t_3 - t_4) + L = 1 \times 1 \times (250.3 - 105) + 945.1 = 1090.4.$

Then: $\frac{1494}{1090.4} = 1.37$ lbs. of steam per hour are required.

Allow 16 per cent to above quantity for heat transmission losses, due to the separation of oil from steam by plate).

Therefore: 1.37 + 16 per cent = 1.59 pounds of steam per hour are required.

In which:

W_2 = Pounds of oil to be heated per hour.
S = Specific heat of oil.
t^1 = Temperature of oil outlet deg. F.
t_2 = Temperature of oil inlet deg. F.
W_1 = One pound of steam @ pressure — p.
S_1 = Specific heat of steam.
t_3 = Temperature of steam @ pressure — p.
L = Latent heat of steam @ pressure — p.
$t_4 = t_2 + 5°$ F.

(205) Formula to Calibrate the Contents of Horizontal Cylindrical Tanks (Flat Heads) at Various Levels, if Segment Does Not Exceed a Semi-Circle.—Given radius (R) of tank and depth (H) of liquid. (See Fig. 13).

Proceed as follows:

$$C = 2\sqrt{R^2 - (R - H)^2}$$

$$W = \frac{S \times H \times C \times L}{231}$$

In which:

W = Liquid contents of tank in gallons.
H = Depth of liquid contents, inches.

L = Length of tank, inches.
R = Inside radius of tank, inches.
C = Chord length, inches.
D = Diameter of tank, inches.

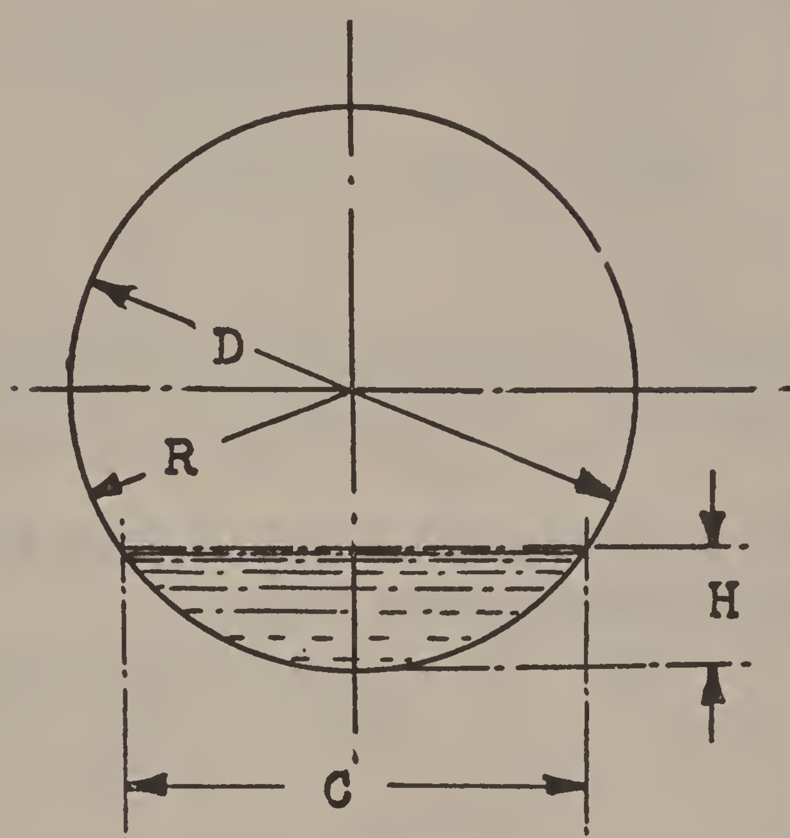


Fig. 13.

VALUES OF S

$\frac{H}{C}$	S	$\frac{H}{C}$	S	$\frac{H}{C}$	S
.01	.6667	.18	.6836	.35	.7280
.02	.6669	.19	.6855	.36	.7313
.03	.6671	.20	.6875	.37	.7347
.04	.6675	.21	.6896	.38	.7382
.05	.6680	.22	.6918	.39	.7418
.06	.6686	.23	.6941	.40	.7455
.07	.6693	.24	.6965	.41	.7493
.08	.6701	.25	.6989	.42	.7531
.09	.6710	.26	.7014	.43	.7569
.10	.6720	.27	.7040	.44	.7608
.11	.6731	.28	.7067	.45	.7648
.12	.6743	.29	.7095	.46	.7688
.13	.6756	.30	.7124	.47	.7729
.14	.6770	.31	.7154	.48	.7770
.15	.6785	.32	.7185	.49	.7812
.16	.6801	.33	.7216	.50	.7854
.17	.6818	.34	.7248		

For example:
$R = 18''$.
$H = 6''$.
$L = 40''$.
What is the contents of the tank?
The solution:

$$C = 2\sqrt{18^2 - (18 - 6)^2} = 26.8''$$

$$S = \frac{H}{C} = \frac{6}{26.8} = 0.22$$

then,

Under column $\frac{H}{C}$, 0.22 corresponds with 0.6918 in column S.

$$\frac{0.6918 \times 6 \times 26.8 \times 40}{231} = \frac{4448.8}{231} = 19.2^{+} \text{ gals., (ans.)}$$

(206) How to Calculate the Amount of Steam Necessary, and the Size of Steam Heating Coil for Tanks.—

$$X = \frac{(T + T_1) \times 0.5 \times (a + a_1 + a_2)}{1000}$$

$$L = \frac{(T + T_1) \times 0.5 \times (a + a_1 + a_2)}{(T_2 - T) \times 10} \div A$$

In which:
X = Pounds of steam required per hour.
L = Lineal feet of pipe necessary in heating coil.
A = External area per one lineal foot of pipe.
T = Desired temperature of oil in tank, deg. F.
T_1 = Atmospheric temperature, deg. F.
a = Area of tank shell in square feet.
a_1 = Area of tank roof in square feet.
a_2 = Area of tank bottom in square feet.
T_2 = Temperature of steam, deg. F.

(206-A) To Determine Motor Size for Centrifugal Pumps.—

$$HP = \frac{G \times P}{1714.3 \times E} + F,$$

HP = Horse power of motor.
G = Gallons per minute to be delivered.
E = See table below.

P = Pressure against which pump operators in pounds per square inch.

F = Factor of safety $\begin{cases} \text{0.20 for motors of 50° temp., rise type.} \\ \text{0.05 for motors of 40° temp., rise type.} \end{cases}$

Capacity of pumps in G. P. M.	Values of E
5 to 25	.25
25 to 55	.30
55 to 100	.35
100 to 200	.45
200 to 400	.50
400 to 600	.55

(207) How to Calculate the Necessary Square Feet of Cooling Surface Required for Residuum Coolers.—When the still is half full then;

$$P = \tfrac{1}{2} \times (0.14 \times d^2 \times l) \times 42 \times g.$$

When the still is less than half full, (see Section 205) the method of computing the still's contents which are in this formula (Section 205) equated in gallons may be expressed by this formula;

$$P = W \times g$$

$$\text{B. t. u.} = \left(\frac{P}{Y}\right) \times S \times (T_1 - T_2)$$

$$M = \frac{(T_1 - t_2) - (T_2 - t_1)}{\text{Log,}^1 \left(\frac{T_1 - t_2}{T_2 - t_1}\right)}$$

$$Q = \frac{\text{B. t. u.}}{(M - h)}$$

In which:

P = Total weight of residuum to be cooled, in pounds.

d = Diameter of still, in feet.

l = Length of still, in feet.

g = Weight of residuum per gallon, in pounds.

T_1 = Temperature of residuum entering cooler, deg. F.

[1] Naperian Logarithm.

T_2 = Temperature of residuum leaving cooler, deg. F.
t_1 = Temperature of water entering cooler, deg. F.
t_2 = Temperature in water leaving cooler, deg. F.
B.t.u. = Heat to be absorbed by water.
S = Specific heat of residuum, (0.50 is safe to consider in this case).
Q = Cooling surface in square feet necessary in cooler, to cool residuum.
Y = Allowable period of time in hours for pumping out still.
M = Mean temperature difference, deg. F.
h = Heat transfer B. t. u.'s per square feet, per deg. of M, (25 is safe to use).
W = Still contents in gallons as calculated by formula in Section 205.

Where the residuum coolers are placed directly upon the ground, the earth beneath them should be firmly tamped in order to sustain the total weight without any subsequent settlement. The area which is occupied by the coolers should be provided with a sand cushion from 2″ to 4″ thick (use only clean sharp sand). The top surface of this sand cushion should be sprayed with a heavy petroleum residue. Before lowering coolers upon the sand cushion the entire bottom (outside) area should be given one coat of Bitumastic paint.

(208) Method of Distributing Petroleum By-Products..—Refined oils are distributed in 1,500-gallon to 12,500-gallon tank cars. These tank cars are loaded so they are shell-full at a temperature of 60° F., upon which basis all petroleum by-products are marketed.

The common containers are either wood or steel barrels; in addition to the following: one-half barrel, (14 to 17 gallons), 1 gallon cans (12 per each case), and 5 to 50-pound slip-top cans, usually for greases.

The manufacture of wooden barrels is an important point in the marketing of refined oils. All oil barrels must be perfectly tight and free from foreign matter, which are liable to contaminate the product shipped in them, and it is therefore necessary that the barrels are properly driven cleaned, glued and dried.

The barrels are usually dried with a hot air fan.

The manufacture of steel barrels is an important industry today due to the increasing demand among the marketers of petroleum products. The foreign countries were among the first to use steel barrels. Steel barrels must stand varying abuses, and for this purpose they must be light in weight to be easily handled and yet substantial enough to retain their shape, the principle item being that they should be free from leakage; experience has proven that a zinc coating reduces interior corrosion. The Inter-State Commerce Commission bureau, under the supervision of Colonel Dunn has encouraged the use of steel barrels for shipment of inflammable articles, any barrel used for this purpose must be marked as complying with specification No. 5 For specifications of wood barrels see Section 209. For specifications of steel barrels see Section 210.

Lubricating oils and greases are usually filled in brightly colored cans; of course this method requires considerable space for storage and much detail work, nevertheless it has proved very satisfactory.

BARREL DATA.

$V =$ Volume of barrel in gallons.

D[1] $=$ Mean diameter of barrel in inches.

$L =$ Length of barrel in inches.

Formula:

$V = D^2 \times L \times 0.0034.$

Wooden barrels when new weigh 68 pounds each, and when old weigh 0.05 per cent additional.

(209) Specifications for Oil and Grease Barrels.—

[1] Mean diameter equals one-half the sum of the head and bung diameters respectively.

No.	Size	Wood	Hoops	Bung	Coating	Use
1	50–52 Gal.	¾ White oak tight sap	Six — 17 and 18 gauge	2″ Bilge	Glue or silicate test (buyer's option)	Only for special, difficult work—alcohol and spirits
2	"	¾ White and chestnut oak	"	"	Glue or silicate test (buyers' option)	I. C. C.—ten specific, inflammable oils with flash point above 20° F., *viz*: shellac, Japan varnish, leather dressing and similar products.
3	"	Same except 1″ heads	Six — 16, 17 and 18 gauge	"	"	I. C. C.—nine specific, inflammable oils with flash point below 20° F., *viz:* naphtha, gasoline, benzene, ether, rubber cement or other products containing one of these as a body.
4	"	¾ White and chestnut oak	Six — 18 and 19 gauge	"	"	Common oil barrel. Light lubricating oils, road oils, linseed oil, etc.
5	"	¾ White and chestnut oak, selected sound sap stock	"	"	"	Thin or penetrating oils, *viz:* turpentine, burning oils, dryers, cottonseed oil. (Cottonseed always in silicated barrels.)
6	"	¾ Red oak	Six — 17 and 18 gauge	"	"	I. C. C.—ten specific, heavy, inflammable oil products with flash point above 20° F. Paints, heavy varnishes, etc.
7	"	"	Six — 18 and 19 gauge	"	"	Common oil barrel. Heavy lubricating oils, black oil, etc.
8	55–60 Gal.	¾ Gum	Six — 18 and 19 gauge	"	"	Common grease or glucose barrel. Oil soap, grease and oils that pour thick.

NOTE:—If eight hoops or finished coating is desired mention that in connection with above numbers.

NOTE:—For other sizes, merely specify size and number. For example: 32-gallon No. 3, 60-gallon No. 7, etc. Most shops can supply the following standard sizes: 5, 10, 15, 20, 25, 32, 40, 45, 52, 55, 60-gallon. Odd sizes mean special work and higher prices, do not use them unless a standard size is impossible.

(210) Shipping Container Specification No. 5 (Iron or Steel Barrels or Drums.—For provisions and restrictions governing the use of these containers, see packing requirements in Freight and Express Regulations.—Revised January 1, 1923.

NOTE.—Specification No. 5A covers these containers for the transportation of acids.

MATERIAL.

1. The minimum thickness of material in any part of the completed barrel or drum must not be less than that prescribed in paragraph 2 (*a*). (Gauge mentioned in this specification refers to United States Standard).

2. (*a*) In the interpretation of the minimum thickness of metal allowed for any special gauge, a variation, due to commercial conditions of manufacture, of not more than 2½ per cent below the specified standard will be considered satisfactory provided the average weight per square foot is not less than the standard weight for the gauge specified. The standard thicknesses and weights prescribed are as follows:

Nominal capacity	Gauge (U. S. St'd.)	Standard weight per sq. ft. (lbs.)	Minimum thickness)2½ % under standard) (inches)
10 gal. or less	20	1.500	0.037
	19[1]	1.750	0.043
11 to 35 gal.	18	2.000	0.049
	17[1]	2.250	0.055
36 to 55 gal.	16	2.500	0.061
	15[1]	2.812	0.069
56 to 110 gal	14	3.125	0.076
	13[1]	3.750	0.091

(*b*) The weight of a barrel or drum with a nominal capacity of 50 to 55 gallons must be not less than 70 pounds in the black exclusive of the rolling hoops.

(*c*) The weight of a barrel or drum with a nominal capacity of 100 to 110 gallons must be not less than 130 pounds in the black exclusive of the rolling hoops.

[1] See paragraph 6.

Rolling Hoops.

3. Rolling hoops swedged or rolled into the shell are not permitted: *Provided,* That containers of the cylindrical or straight-side type of not over 55 gallons nominal capacity may have the rolling hoops swedged or rolled into the shell or body if both the shell and heads are made from materials at least two gauges thicker than as prescribed in paragraph 2.

4. Separate rolling hoops as prescribed must be properly secured to the shell, preferably by means of small bead on each side of each rolling hoop or by welding for a length of 3 or 4 inches at several points around the circumference; spot welding or beading under the rolling hoop is not authorized.

5. Containers of the cylindrical or straight-sided type with a nominal capacity of over 10 gallons must be equipped with separate rolling hoops, either of the U-shaped sheet-metal type at least two gauges heavier than the steel in the shell of the container or of the solid I-bar type of not less than commercial ¾ inch by 1¼ inches, weighing not less than 1.25 pounds per foot; containers of this type are not required to have rolling hoops if of 10 gallons or less nominal capacity.

6. Bilge-type containers need not be equipped with rolling hoops if the minimum thickness of the metal in the shell is 14 gauge at the bilge and 15 gauge at other points for a container of 35 gallons or less nominal capacity, and 13 gauge at the bilge and 14 gauge at other points for a container of over 35 but not over 55 gallons nominal capacity; if lighter material is used or if the container is over 55 gallons nominal capacity, rolling hoops must be attached in accordance with the provisions covering the cylindrical or straight-sided container.

Tests.

7. Each barrel or drum must be tested, under water or with all seams covered with soap-suds or heavy oil, by interior compressed air at a pressure of not less than 15 pounds per square inch and must be carefully examined while under this pressure and must stand this test without leaking.

8. The type of barrel or drum must be capable of standing, without leaking, a hydrostatic test pressure of not less than 40 pounds per square inch sustained for not less than five minutes.

Any distortion of the heads due to this test must be such that they can be restored approximately to their original position (by hammering with a wooden maul or similar means) without leakage, when subjected to a 15-pound air-pressure test.

9. When filled with water to 98 per cent of its capacity the type of barrel or drum must also be capable of standing without leakage a test by dropping it diagonally on its chime from a height of 4 feet upon a solid concrete foundation.

10. Type tests of sample packages must be made, by any company starting production, on each type and size of package in order to insure that the product will comply with paragraphs 8 and 9, and these tests must be repeated at intervals of not more than four months: if the same type and size is to be made of different gauge material the samples must be taken from those of the lighter gauge. Subsequent production on any type or size of package must not be continued unless further tests have been made within the previous four months; if production has been discontinued and is resumed, this requirement will also apply. Tested packages must be held available for inspection until the next test on the same type and size is made.

Bung Closures.

11. Provision must be made for closing the bung-holes and other openings in such manner as to prevent leakage. Bungs or other closing devices projecting beyond the chime or rolling hoops must be capable of withstanding the same test drop as prescribed by paragraph 9. Threaded metal bungs and plugs must be close-fitting, and threads in the reinforcements and on the plugs must be cut at right angles to the faced surfaces thereof so that when bungs are inserted (without gaskets) the faced surface of the bung will bear squarely on the faced surface of the reinforcement or spud. The spud should have not less than five complete threads and the threading on the bung should be of sufficient length so that, with gaskets in place, it will engage in all of the five threads in the spud.

Gaskets must be made of lead, vulcanized fiber, leather, or other suitable material, not less than ⅛ inch thick and not less than ¼ inch across the face.

To insure tight closure of the bung, etc., it is advisable that the gaskets and the flanges of the bung and filling hole be coated with a suitable luting substance, such as gum shellac dissolved in alcohol to about the consistency of molasses, glue, or a rosin and soap compound, etc. After applying such luting the bung should be set down tight with a wrench having a handle at least 18 inches long. The barrel should then be allowed to stand on end for a few hours until the luting dries, after which the barrel should be placed on its side, bung down, to test for leakage before being offered for shipment.

Wooden bungs must be compressed tapered bungs, and must be covered with a suitable coating and have a driving fit into a smooth bung-hole tapered the same as the bung.

Wooden bungs should be long enough to extend about ⅛ inch inside of the barrel and should be soaked in hot water or hot, thin glue for about a minute before driving into the bung-hole so that the interior of the bung will swell and form a shoulder on the inside of the bung-hole.

Manufacturing Methods.

12. The method of manufacturing the barrel or drum and the materials used must be well adapted to producing a uniform product. Leaks caused by defective manufacture of a barrel or drum must not be stopped by soldering but must be repaired by the method used in constructing the barrel or drum.

It is recommended that, when nature of contents will permit, each such container should be coated on the inside and outside in such manner and with such materials as will prevent corrosion.

13. All metal barrels or drums having a capacity of 30 United States wine gallons or over, being manufactured with a flanged type of head secured to the body sheet by welding or by a double seam, must have the chime adequately protected by some chime reinforcement.

Marking.

14. Each barrel and drum must be plainly and permanently marked by embossing or stamping on the head as follows:

(*a*) The marking I. C. C.—5.

(*b*) Marking to show the United States Standard gauge of the metal in its thinnest part, the nominal capacity of the container in gallons, and the year of manufacture. These may be abbreviated and then must appear in the order specified (for example, 16-55-20, which will signify that the container is made of 16 gauge steel, is of 55 gallons capacity, and was made in the year 1920).

(*c*) The name, initials, or symbol of the manufacturer. (This must be recorded with the Bureau of Explosives, 30 Vesey Street, New York City).

The marking I. C. C.—5 shall be understood to certify that the container complies with all the requirements of this specification.

The size of marking, letters, and figures, must be a minimum of ½ inch for 35 gallons or smaller containers, ¾ inch for containers over 35 but not over 55 gallons, and 1 inch for containers over 55 but not over 110 gallons.

If the marking as specified in paragraph 14 (*b*) is not abbreviated as allowed therein, then the gallonage of the container may be placed on a brass plate securely fastened to the container.

15. When offered for shipment the container must also bear such other description as may be required by these regulations for the particular article contained therein.

Inspection.

16. Wherever practicable the manufacture of these barrels or drums should be subjected to the inspection of a competent and disinterested inspector.

Reports of Manufacture.

17. All manufacturers who make metal barrels or drums to comply with this specification must forward to the chief inspector, Bureau of Explosives, 30 Vesey Street, New York City, a

monthly report of all such barrels or drums shipped. Such report must be submitted in the following form:

(Place) ....

(Date) ....

Bureau of Explosives,
30 Vesey Street, New York, N. Y.

Gentlemen: Report of metal[1] ....shipped by us from ....during the month of ....made under requirements of I. C. C. specifications.

I. C. C. spec'n. No.	Nominal capacity (gals.)	Gauge of material (U. S. standard) Head	Body	Date marked on container	No. of containers	Minimum weight in the black[2] (lbs.)	Date of last type tests[3]
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....

Each container was tested under an air pressure of .... pounds as required and showed no leakage.

We hereby certify that these containers are properly marked and comply in all respects with the requirements of the I. C. C. specifications.

(Signed)..........................

(Per)..........................

(210-A) Shipping Container Specification No. 5A (Iron or Steel Barrels or Drums.—For provisions and restrictions governing the use of these containers, see packing requirements in Freight and Express Regulations.—Revised January 1, 1923.

NOTE.—Removable head or removable plate containers not authorized under this specification.

MATERIAL.

1. The minimum thickness of material in any part of the completed barrel or drum must not be less than that prescribed

[1] Insert "barrels" or "drums."
[2] Excluding rolling hoops.
[3] Must be made every four months.

in paragraph 2. (Gauge mentioned in this specification refers to United States Standard).

2. In the interpretation of the minimum thickness of metal allowed for any specified gauge, a variation, due to commercial conditions of manufacture, of not more than 2½ per cent below the specified standard will be considered satisfactory provided the average weight per square foot is not less than the standard weight for the gauge specified. The standard thickness and weights prescribed are as follows:

Nominal capacity	Gauge (U. S. st'd)	Standard weight per sq.ft. (lbs.)	Minimum thickness (½% under standard) (inches)
29 gal or less	16	2.500	0.061
	15[1]	2.812	0 069
30 to 55 gal.	14	3.125	0.076
	13[1]	3.750	0.091
56 to 110 gal.	12	4.375	0.107

It is recommended that the materials from which these containers are manufactured shall be of the highest acid-resisting qualities obtainable.

Rolling Hoops.

3. Rolling hoops or beads swedged or rolled into the shell at any point are not permitted.

4. Separate rolling hoops, as prescribed, must have a tight fit on the shell and must be firmly secured in position by ridges or lugs applied to the shell by welding. These ridges or lugs must not be less than 3 inches long each, nor less than ⅛ inch in height, and must be so placed that they are in pairs on opposite sides of each rolling hoop. There must be not less than four pairs of these ridges or lugs for each hoop, spaced approximately evenly about the circumference of the shell. Spot welding or beading is not authorized.

5. Containers of the cylindrical or straight-sided type with a nominal capacity of over 10 gallons must be equipped with separate rolling hoops of the solid I-bar type, not less than commercial ¾ inch by 1¼ inches, weighing not less than 1.25 pounds per

[1] See paragraph 6.

foot for containers not over 35 gallons nominal capacity, and not less than commercial 1 inch by 1½ inches, weighing not less than 1.6 pounds per foot for containers over 35 gallons nominal capacity. Containers of this type are not required to have rolling hoops if of 10 gallons or less nominal capacity. (Effective March 26, 1924).

6. Bilge-type containers need not be equipped with rolling hoops if the minimum thickness of the metal in the shell is 14 gauge at the bilge and 15 gauge at other points for a container of 29 gallons or less nominal capacity, and 13 gauge at the bilge and 14 gauge at other points for a container of over 29, but not over 55 gallons nominal capacity; if lighter material is used or if the container is over 55 gallons nominal capacity, rolling hoops must be attached in accordance with the provisions covering the cylindrical or straight-sided container.

Tests.

9. Each barrel or drum must be tested, under water or with all seams covered with soap-suds or heavy oil, by interior compressed air at a pressure of not less than 15 pounds per square inch and must be carefully examined while under this pressure and must stand this test without leaking.

8. The type of barrel or drum must be capable of standing, without leaking, a hydrostatic test pressure of not less than 80 pounds per square inch sustained for not less than five minutes.

Any distortion of the heads due to this test must be such that they can be restored approximately to their original position (by hammering with a wooden maul or similar means) without leakage, when subjected to a 15-pound air-pressure test.

9. When filled with water to 98 per cent of its capacity the type of barrel or drum must also be capable of standing without leakage a test by dropping it diagonally on its chime from a height of 6 feet upon a solid concrete foundation.

10. Type tests of sample packages must be made, by any company starting production, on each type and size of package, in order to insure that the product will comply with paragraphs 8 and 9, and these tests must be repeated at intervals of not more than four months; if the same type and size is to be made of dif-

ferent gauge material the samples must be taken from those of the lighter gauge. Subsequent production on any type or size of package must not be continued unless further tests have been made within the previous four months; if production has been discontinued and is resumed, this requirement will also apply. Tested packages must be held available for inspection until the next test on the same type and size is made.

Bung Closures.

11. Provisions must be made for closing the bung holes in such manner as to prevent leakage. Plugs or other closing devices projecting beyond the chime or rolling hoops must be capable of withstanding the same drop test as prescribed by paragrph 9 of this specification.

Gaskets must be made of asbestos or other suitable acid-resistant material, not less than $\frac{1}{8}$ inch thick, and not less than $\frac{1}{4}$ inch across the face.

Threaded metal flanges and plugs must be close fitting and the threads in the flanges and on the plugs must be cut at right angles to the faced surfaces thereof, so that when plugs are inserted (without gaskets) the faced surface of the plug will bear squarely on the faced surface of the flange. The flange must have not less than five complete threads, and the threading on the plug must be of sufficient length, so that with the gasket in place it will engage in all of the five threads in the flange.

For containers of over 35 gallons nominal capacity, the flange must have an outside extreme diameter of $3\frac{1}{2}$ inches, a diameter across the face of $2\frac{3}{4}$ inches, and a minimum thickness of $^{11}/_{16}$ inch; these measurements must be accurate within the limits of commercial manufacture. Flanges may be made of Monel or other highly acid-resistant metal.

For containers of over 35 gallons nominal capacity, the plugs and the threading on plugs and flanges must be made in form and dimensions according to the drawing accompanying (see Fig. 13A, page 150) and made a part of this specification. Plugs may be made of cast iron, although this is not recommended.

For containers of 35 gallons or less nominal capacity, it is recommended that the same construction of flange and plug, and

the same form of thread, be used, but with dimensions suitable to the size of the container. (Effective March 26, 1924).

MANUFACTURING METHODS.

12. The method of manufacturing the barrel or drum and the materials used must be well adapted to producing a uniform product. Leaks caused by defective manufacture of the barrel or drum must not be stopped by soldering, but must be repaired by the method used in constructing the barrel or drum.

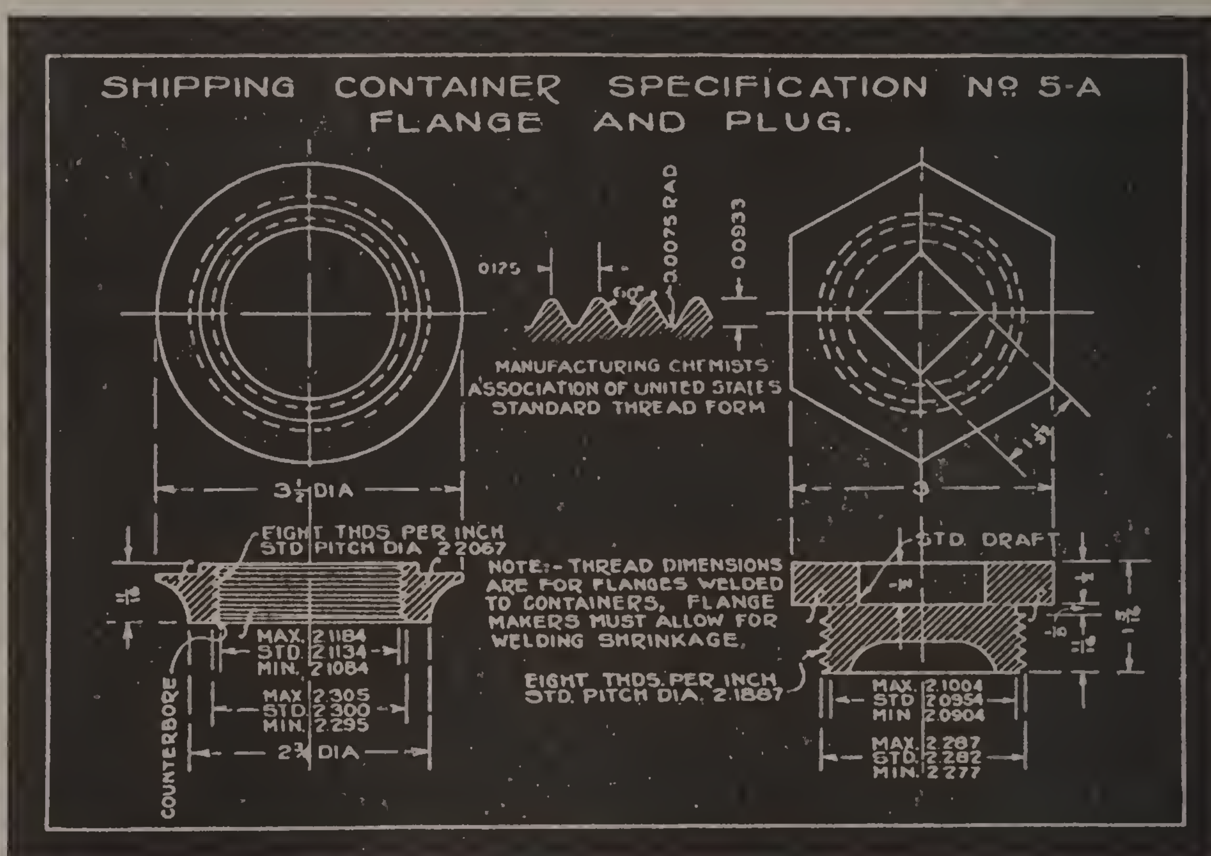


Fig. 13A.

All body seams must be welded, all flanges must be welded to the sheet or head, and all head or chime seams must be welded or double seamed.

It is recommended that, when the nature of the contents will permit, each such container should be coated on the inside and outside in such manner and with such material as will prevent corrosion. (Effective March 26, 1924).

13. All metal barrels or drums having a capacity of 30 United States wine gallons or over being manufactured with a flanged type of head secured to the body sheet by welding or by a double seam must have the chime adequately protected by some chime reinforcement.

Marking.

14. Each barrel and drum must be plainly and permanently marked by embossing or stamping on the head as follows:

(*a*) The marking I. C. C.—5A.

(*b*) Marking to show the United States Standard gauge of the metal in its thinnest part, the capacity of the container in gallons, and the year of manufacture. These may be abbreviated and then must appear in the order specified (for example, 16-55-20, which will signify that the container is made of 16-gauge steel, is of 55 gallons capacity, and was made in the year 1920).

(*c*) The name, initials, or symbol of the manufacturer. (This must be recorded with the Bureau of Explosives, 30 Vesey Street, New York City).

The marking I. C. C.—5A shall be understood to certify that the container complies with all the requirements of this specification.

The size of marking, letters, and figures must be a minimum of ½ inch for 35 gallons or smaller containers, ¾ inch for containers over 35 but not over 55 gallons, and 1 inch for containers over 55 but not over 110 gallons.

15. When offered for shipment the container must also bear such other description as may be required by these regulations for the particular article contained therein.

Inspection.

16. Wherever practicable the manufacture of these barrels or drums should be subjected to the inspection of a competent and disinterested inspector.

Reports of Manufacture.

17. All manufacturers who make metal barrels or drums to comply with this specification must forward to the chief inspector, Bureau of Explosives, 30 Vesey Street, New York City, a monthly report of all such barrels or drums shipped. Such report must be submitted in the following form:

(Place) ....
(Date) ....

Bureau of Explosives,
30 Vesey Street, New York, N. Y.

Gentlemen: Report of metal[1] ....shipped by us from ....during the month of ....made under requirements of I. C. C. specifications.

I. C. C. spec'n. No.	Nominal capacity (gal.)	Gauge of material (U. S. standard) Head	Body	Date marked on containers	No. of containers	Minimum weight in the black (lbs.)[2]	Date of last type tests[3]
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....

Each container was tested under an air pressure of .... pounds as required and showed no leakage.

We hereby certify that these containers are properly marked and comply in all respects with the requirements of the I. C. C. specifications.

(Signed)..........................
(Per)..........................

(210-B) Shipping Container Specification No. 5B (Iron or Steel Barrels or Drums.—For provisions and restrictions governing the use of these containers, see packing requirements in Freight and Express Regulations.—Approved January 1, 1923.

NOTE.—See specification No. 5 for containers of inflammable liquids with flash point below 20° F. and specification No. 5A for containers of acids.

1. These containers must be manufactured, tested, and reported in full compliance with all of the requirements of Interstate Commerce Commission specification No. 5, with the following exceptions (gauge mentioned in this specification refers to United States Standard):

[1] Insert "barrels" or "drums."
[2] Excluding rolling hoops.
[3] Must be made every four months.

2. Rolling hoops swedged or rolled into the shell or body of containers of the cylindrical or straight-sided type are authorized for containers of not over 55 gallons nominal capacity without increasing the thickness of material used as required by paragraph 3, specification No. 5; rolling hoops swedged or rolled into the shell or body of containers of the cylindrical or straight-sided type are authorized for containers of over 55 gallons nominal capacity if the material from which the containers are made is not less than No. 13 gauge; reduction of the minimum thickness of material by this operation shall not be considered as a violation of this specification.

3. Bilge-type containers need not be equipped with rolling hoops if the minimum thickness of the metal in the shell is not less than 16 gauge for a container of 35 gallons or less nominal capacity and not less than 14 gauge for a container over 35 but not over 55 gallons nominal capacity.

4. The marking embossed or stamped on the head of the container shall be as follows:

(*a*) The marking I. C. C.—5B.

(*b*) Marking to show United States Standard gauge of the metal in its thinnest part, the capacity of the container in gallons, and the year of manufacture. These may be abbreviated and then must appear in the order specified (for example, 16-55-20, which will signify that the container is made of 16-gauge steel, is of 55 gallons capacity, and made in the year 1920).

(*c*) The name, initials or symbol of the manufacturer. (This must be recorded with the Bureau of Explosives, 30 Vesey Street, New York City).

The marking I. C. C.—5B shall be understood to certify that the container complies with all the requirements of this specification.

The size of marking, letters, and figures must be a minimum of ½ inch for 35 gallons or smaller containers, ¾ inch for containers over 35 but not over 55 gallons and 1 inch for containers over 55 but not over 110 gallons.

(211) Perfect Steam Boiler Requirements.—(*a*) Proper workmanship with simple construction and using materials which ex-

perience points to be the best, thereby avoiding the necessity of early repairs.

(*b*) A mud drum to catch all impurities settled from the water, and so placed as to be removed from the action of the fire.

(*c*) A water and steam capacity sufficient to prevent any fluctuation in water level or steam pressure.

(*d*) A water surface of sufficient extent for the disengagement of the steam from the water to prevent foaming.

(*e*) A constant and thorough circulation of water throughout the boiler, so that all parts maintain the same temperature.

(*f*) The water space divided into sections arranged so, that, should any section fail, no general explosion can occur and the destructive effects will be confined to the escape of the contents. Large and free passages between the different sections to equalize the water line and pressure in all.

(*g*) The boiler should be so constructed as to be free from strains due to expansion, and, if possible, to avoid joints exposed to the direct action of the fire.

(*h*) A combustion chamber arranged so that the combustion of the gases started in the furnace may be completed before the gases escape through the chimney.

(*i*) The heating surface as nearly as possible at right angles to the currents of heated gases in order to break up the currents and extract all the available heat from the gases.

(*j*) All parts to be readily accessible for cleaning and repairs. This is one point of great importance as regards safety and economy.

(*k*) Proportioned for the work to be done, and capable of working to its full rated capacity with the highest economy.

(*l*) Equipped with the very best gauges, safety valves and other fixtures.

(212) Painting Data.—All painters' work is usually estimated by the yard and the cost generally depends upon the number of coats applied together with the quality of the work and the material that is to be painted.

The first coat (usually called priming) will require 20 pounds of lead and 4 gallons of oil to paint 100 yards.

The first and second coat will require 40 pounds of lead and 4 gallons of oil.

1 Gallon of priming color will cover 50 superficial yards.

1 Gallon of white zinc will cover 50 superficial yards.

1 Gallon of white paint will cover 12 per cent less.

1 Gallon of green paint will cover 10 per cent less.

1 Gallon of tar and 1 pound of pitch will cover 12 superficial yards for the first coat, and 50 per cent more will be required for the second coat.

An approximate rule to compute the required amount of paint for a given surface is as follows:

S = Square feet of surface to be painted.

n = Number of pounds of pure ground white lead required for three coats.

N = Number of gallons of liquid paint required for two coats.

$$C = \begin{cases} 200 \text{ used when solving for N.} \\ 18 \text{ used when solving for n.} \end{cases}$$

Hence:

$$N = \frac{S}{C}$$

$$n = \frac{S}{C}$$

(213) Annual Percentage of Depreciation on Machinery and Miscellaneous Equipment.—

Type	Percentage
Auxiliaries, steam	3-6
Boilers	4-5
Generators (driven by belt)	5
Motors	5
Miscellaneous shop tools	5-11
Steam piping	4-7
Steam engines	4-6
Steam turbines	3-5
Switch boards	3-5
Wire rope	4-5

(214) Machine Designing (Rules).—The following are rules of practical experience which are often neglected by inexperienced designers:

1. All parts that are subject to wear or breakage should be made accessible for the purpose of inspection, repairs, or renewal.

2. Means for adjusting all parts that are subject to wear should be provided.

3. Links and rotating pieces for guiding motion in preference to slides should be used.

4. Careful provision for lubrication should be made.

5. Cranks, levers, belts, and gear wheels should be used for transmitting motion in preference to cams, screws or worm wheels.

6. Whenever possible the motion of all parts should be made positive that is—avoid the use of weights or springs for providing motion.

7. Through bolts or T-headed bolts should be used instead of tap bolts or studs wherever it may be done.

(215) Clearances for Box Cars.—(See Fig. 14).

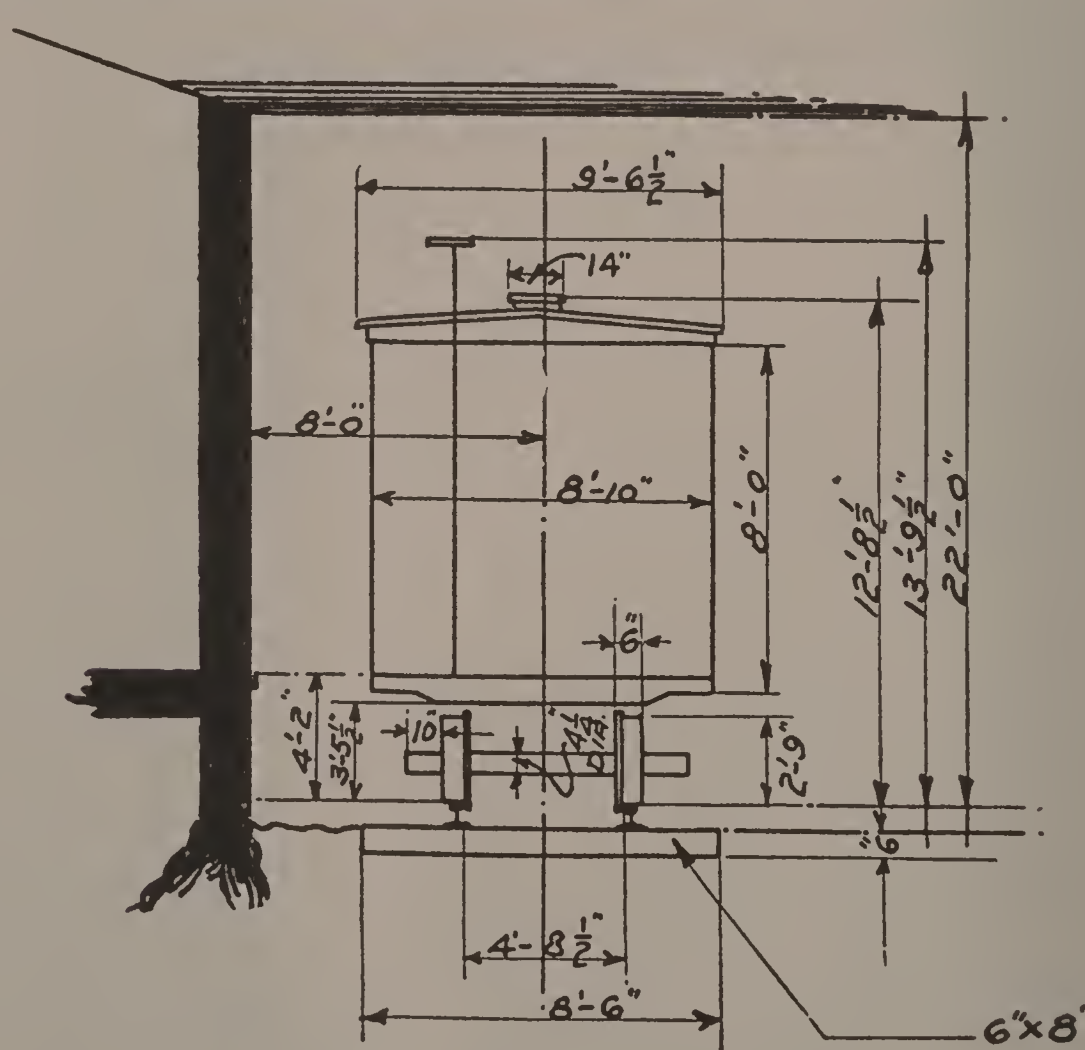
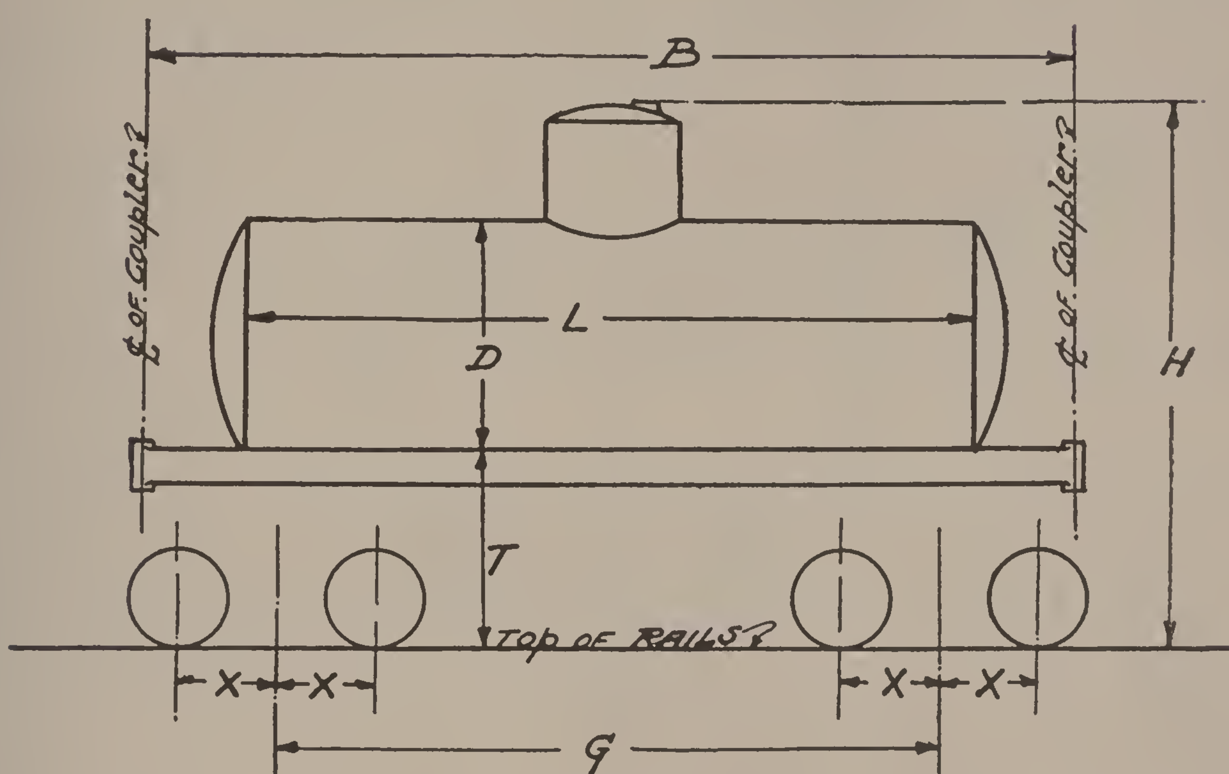


Fig. 14.

The widest car is about 10 feet. Coal cars are about the same width as box cars, but 10 feet high.

(215-A) Clearances for Tank Cars.—(See Fig. 15).



CAPACITY OF CAR	WEIGHT OF CAR EMPTY, IN LBS.	D	L	B	H	T	G	X
6000-GALLONS	35,350	73½"	27'-0"	35'-1½"	12'-0 15/16"	3'-8 5/8"	22'-8"	2'-8"
8000-GALLONS	41,200	83"	28'-0"	35'-1½"	13'-2¾"	3'-8 5/8"	22'-8"	2'-8"
10,000-GALLONS	44,750	92½"	28'-0"	35'-1½"	14'-5 3/8"	3'-8 5/8"	22'-8"	2'-8"

(Contributed by American Car & Fd'y Co.)

DATA AND CLEARANCES FOR TANK CARS

Fig. 15.

(215-B) Specifications for a Locomotive.—(See Fig. 16).

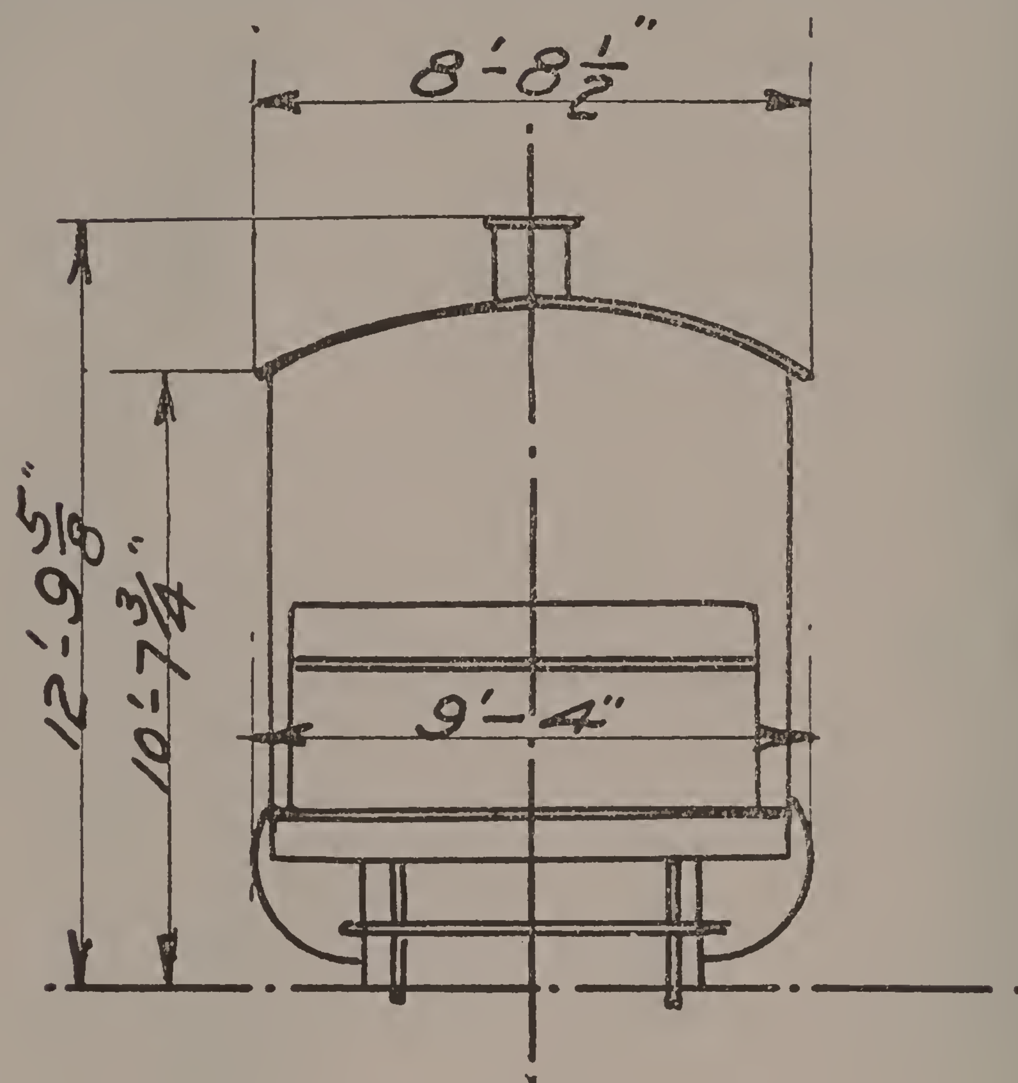


Fig. 16.

SPECIFICATIONS.

Cylinders, 17" x 24".
Centre of cylinders, 7' 2½".
Centre of slide valves, 6' 8".
Centre of frame, 3' 11".
Driving journals, 7" x 9".
Water tests, 240 lbs.
Fire box inside, 4' 6" x 2' 10⅝".
Tubes, 150—2" O. D. x 13'0" long.
Heat surface, 1096 sq. ft.
Capacity of tanks, 1000 gals.
Gauge of track, 4' 8½".
Diameter of drivers, 3' 8".
Overall length, 31' 8⅜".

Wheel base, 5′ 2″ (Front).
Wheel base, 4′ 8″ (Rear).

(216) Regeneration of Acid Sludge in a Modern Refinery.—
Equipment: A. A separator for removing tarry substance from the acid sludge, which is a shallow chemical lead pan, with hood; the size of the pan is 12′ wide x 50′ long and 12″ deep. This pan is equipped with a steam heating coil.

B. Three shallow weak acid (16 lb.) chemical lead pans 6′ wide x 40′ long x 12″ deep, series connected.

C. Two shallow strong acid (16 lb.) chemical lead pans 6′ wide x 40′ long x 12″ deep. Also, two high grade close-grained cast iron stills (with lead hoods), size of stills 3′ x 8′ x 8′ deep, set in brick settings and heated with coal or fuel oil.

D. The building housing the above equipment should be constructed entirely of long leaf yellow pine and be exceptionally well ventilated.

Operation: The operation of the plant to recover the acid consists briefly as follows: The acid sludge is diluted with 50 per cent of water and is pumped into the separator A where it is heated with the steam coil to about 175° F., here the separation of tarry substance is performed by settling. It then flows into the heated weak acid pans B set over hot flues for concentration from 30° to 60° Bé. (for liquids heavier than water) from here it enters the strong acid pans C (heated similarly to the weak acid pans) and leaves these pans at 64° Bé.; finally entering into the cast iron stills (also heated) the regenerated acid *i. e.*, now 66° Bé. acid flows from the last still into storage tanks ready for use in the agitators again.

(217) How to Calculate the Amount of Radiation Required.—

$$\frac{\left[\frac{C \times (t_1 - t_2)}{55}\right] + S \times (t_1 - t_2) \times h_1 + S_1 \times (t_1 - t_2) \times h_2}{E} = R$$

In which:

C = Room contents in cubic feet of air per hour for ventilation.

S = Exposed glass surface in square feet.

S_1 = Exposed net wall surface in square feet.
h_1 = Heat transmission in B. t. u. for glass, see Table I below.
h_2 = Heat transmission in B. t. u. for wall, see Table I below.
t_1 = Room temp., desired deg. F.
t_2 = Min., exterior temp., deg. F.
E = Efficiency of radiators or coils, see Table II on page 161.
R = Radiation required in square feet.

TABLE I.—Heat Transmission in B. t. u.
(Per Sq. Ft. per Hour, per Degree Temperature Difference between Inside and Outside Air).

Glass	
Single window	1.25
Double window	.62
Single skylight	1.50
Double skylight	.75
In monitor, single	1.35
Doors are considered same as windows.	
Ceilings	
Lath and plaster (no floor above)	.40
Lath and plaster (wood floor above)	.36
Roofs	
Patent roofing—paper, tar and gravel	.30
Hollow tile with 2 inches cement, tar and gravel covering	.60
Asphalt	.27
Slate roof with sheathing	.40
Floors	
Double wood flooring, no plaster beneath	.24
Concrete on ground	.40
Wood near ground	.20
Solid Brick Wall	
4 inches thick	.60
8 inches thick	.42
12 inches thick	.30
16 inches thick	.24
20 inches thick	.21
24 inches thick	.19
Concrete Wall	
8 inches thick	.48
12 inches thick	.45
16 inches thick	.39
20 inches thick	.38
24 inches thick	.31
Frame Wall	
Ordinary overlapping clapboards, 7/16-inch	.48
Same with paper lining	.34
Same with 3/4-inch sheathing	.30
Same with 3/4-inch sheathing and paper	.25

TABLE II.—VALUES FOR E (STEAM OR HOT WATER RADIATION).

	Radiation per sq. ft. of surface per hour in B. t. u.	
	Steam radiation	Hot water radiation
C. I. sectional and pipe radiators	250	170
Wall radiators	300	220
Ceiling coils	200–250	120–170
Wall coils	300	220

(218) How to Calculate the Size of Stacks.—

C = Cubic feet of combustion per second.

V = Velocity of gases feet per second. (Average may be assumed at 30 feet per second.)

D = Draft pressure in inches of water.

P = Atmospheric pressure in pounds per square inch.

H = Height of stack in feet.

T = Absolute temperature deg. F. of outside air.[1]

T_1 = Absolute temperature deg. F. of flue gases.[1]

t = Temperature deg. F. of outside air.

t_1 = Temperature deg. F. of flue gases(at stack entrance).

W_1 = Weight of one cubic foot of air @ temp. — t.

W_2 = Weight of one cubic foot of flue gases @ temp. — t_1.

A = Area of stack in square feet.

$$D = \frac{(W_1 - W_2) \times H}{5.197}.$$

$$H = \frac{D}{0.52 \times P \times \left(\frac{1}{T} - \frac{1}{T_1}\right)}$$

$$A = \frac{C}{V}, \text{ (add 15\% to A for friction losses).}$$

(219) Specifications for Wire Rope Used for Oil Well Drilling and Tubing Lines.—The rope used must be standard extra strong crucible cast steel of the 6 x 9 construction, equal to the American Steel & Wire Company's product. It must be composed of one hemp core, six strands having nineteen wires to each strand, made of selected cast steel wires of high tensile strength.

[1] Absolute temperatures are found by adding 460° F. to t and t_1.

The table below illustrates various sizes and capacities.

Diameter in inches	Circumference in inches	Approximate weight per foot in pounds	Approximate strength in tons of 2,000 pounds	Proper working load in tons of 2,000 pounds	Diameter of drum or sheave in feet advised
2¾	8⅝	11.95	243	48.6	11
2½	7⅞	9.85	200	40	10
2¼	7⅛	8	160	32	9
2	6¼	6.3	123	24.6	8
1⅞	5¾	5.55	112	22.4	8
1¾	5½	4.85	99	19.8	7
1⅝	5	4.15	83	16.6	6.5
1½	4¾	3.55	73	14.6	6
1⅜	4¼	3	64	12.8	5.5
1¼	4	2.45	53	10.6	5
1⅛	3½	2	43	8.6	4.5
1	3	1.58	34	6.80	4
⅞	2¾	1.20	26	5.20	3.5
¾	2¼	0.89	20.2	4.04	3
⅝	2	0.62	14	2.80	2.5
9/16	1¾	0.50	11.2	2.24	2.25
½	1½	0.39	9.2	1.84	2
7/16	1¼	0.30	7.25	1.45	1.75
⅜	1⅛	0.22	5.30	1.06	1.50
5/16	1	0.15	3.50	0.70	1.25
¼	¾	0.10	2.43	0.49	1

(220) Specifications for Filling Stations.—(See Figs. 7A, 7B, and 7C.) Plot selection for filling stations is very important and great care must be exercised to avoid conjested boulevards (See Fig. 7A). Corner plots are more desirable and it is absolutely essential to shun the narrow and unpaved streets. Regardless of whatever transactions are consumated it is important to have the land title papers carefully searched. The principals are cautioned not to attempt to evade the local ordinances, building codes, insurance authorities, legislative endorsements or the fire marshal's orders. All tanks and pumps should bear the inspection plate of the National Board of Fire Underwriter's Laboratories.

The building should be entirely or at least, semi-fireproofed. If conditions permit, it is recommended to provide the building with a basement in which the air compressor, heating plant, accessory storage, etc., can be installed (see Fig. 7C). Upon the first floor it is advisable to provide a ladies' rest room. All toilets should have self-draining non-freezing shut-off valves. Upon

the first floor use red quarry tiles or faience tiles. Basement floor should be of concrete having a smooth cement finish. Peaked roofs should have clay tiles, (for less expensive roof covering use metal tile or asbestos shingles). For interior finish use tile or glazed brick with ornamental steel ceiling. For exterior use pressed or wire cut brick, concrete or a combination of concrete and brick with faience inserts. Make satisfactory provisions for installing sanitary and storm water sewers (see Section 198).

Roofs should be provided over driveways to protect patrons from inclement weather when they may desire to leave their automobiles during the replenishing of gasoline, etc. Roof span should be carefully calculated so as to eliminate sagging under wind and snow loads. The use of center supports should be avoided. The driveway should be not less than 13 feet in the clear. The approach at the curb should not be less than 25 feet when approach is used only for one way traffic. All sharp turns and abrupt grade variations should be avoided. Reinforced concrete (driveway) pavement having a smooth cement finish should be constructed. Expansion joints should be provided every 12 feet. The cement finish should be given a coat of hardening liquid. Satisfactory provisions should be made for installing a storm water sewer (see Section 198).

The building should be properly lighted. A building 14′ x 14′ should have at least two 200-watt lamps inside, exclusive of the toilet light. For the exterior provide four 100-watt lamps attached to the eaves. The driveways (see Fig. 7B) also should be well lighted. The wiring in the building is to be placed in metal conduits with approved conduit openings. The wiring for exterior is to be placed under ground and must be lead covered cable laid inside of metal conduit. Switches and fuse boxes are to be of the closed type.

The heating plant should be located in the basement (see Fig. 7C) and is to be either a hot water or hot air system. Filling stations without basements should be heated by a special kerosene burner, or artificial gas radiators. All doors should have movable transoms; only windows that may be lowered from

top and bottom should be used. All toilets should be properly ventilated to roof. Chimney should be of ample size and carefully constructed.

All storage tanks are to be constructed of O. H. steel plates. Galvanized tanks under 1,100 gallons are to be not less than No. 12 gage steel, seams to be securely riveted or spot welded. Larger tanks (that are not galvanized) are to be made of $^3/_{16}''$ steel, thoroughly riveted and caulked or entirely welded, and should be given a coat of varnish (before installation) composed of 4 parts of Portland cement thoroughly mixed cold, and then 3 parts of kerosene oil stirred into sixteen parts of coal tar. Only freshly mixed varnish should be used.

All tanks should be carefully measured and installed perfectly level, at least 4 feet below ground (from top of tank). Tanks are to be firmly anchored to foundation and should be properly vented and placed as close as possible to the pump which they serve. The refilling connection on tank should be at least 3″ diameter, and must be flush with the pavement. The entire piping system should be inspected by the proper city officials before being covered or placed into service. All tanks should be provided with a separate pump. Pumps should be of the 5-gallon size. The testing and sealing of the pump equipment should be executed by the local sealer of weights and measures.

The location of air lines should be carefully considered. Use only ⅜″ diameter armored air hose equipped with the best air chuck attainable. A swinging counter balance arm or revolving reel should be provided to keep the hose above the ground when not in use. The water taps located outside of the building should be equipped with a self-draining non-freezing shut-off valve. The air compressor should be a 2-stage vertical type, mounted on a horizontal tank and driven by an electric motor. Compressor should deliver from 3 to 4 cubic feet of air per minute at 250 r. p. m. and must start automatically when the pressure drops to 100 pounds and cut out when pressure reaches 150 pounds. The size of the electric motor must be from one-half to one H. P.

The air receiver tank should be not less than $^3/_{16}''$ tank steel and must have a capacity from 25 to 40 cubic feet. Tanks should

be tested to a hydrostatic pressure of from 300 to 400 pounds per square inch and the safe working pressure to be not less thau 180 pounds per square inch.

(221) Template for Drilling.—

AMERICAN STANDARD FOR 250 POUNDS.
Effective January 1, 1914.

Size, inches	Diameter of flange	Thickness of flange	Bolt circle	Number of bolts	Size of bolts	Length of bolts	Length of studs with two nuts
1	4½	11/16	3¼	4	½	2¼	—
1¼	5	¾	3¾	4	½	2¼	—
1½	6	13/16	4½	4	⅝	2½	—
2	6½	⅞	5	4	⅝	2¾	—
2½	7½	1	5⅞	4	¾	3	—
3	8¼	1⅛	6⅝	8	¾	3¼	—
3½	9	1 3/16	7¼	8	¾	3½	—
4	10	1¼	7⅞	8	¾	3½	—
4½	10½	1 5/16	8½	8	¾	3¾	—
5	11	1⅜	9¼	8	¾	3¾	—
6	12½	1 7/16	10⅝	12	¾	4	—
7	14	1½	11⅞	12	⅞	4¼	—
8	15	1⅝	13	12	⅞	4½	—
9	16¼	1¾	14	12	1	4¾	—
10	17½	1⅞	15¼	16	1	5	—
12	20½	2	17¾	16	1⅛	5½	—
14	23	2⅛	20¼	20	1⅛	5¾	—
15	24½	2 3/16	21½	20	1¼	6	—
16	25½	2¼	22½	20	1¼	6	—
18	28	2⅜	24¾	24	1¼	6¼	—
20	30½	2½	27	24	1⅜	6¾	—
22	33	2⅝	29¼	24	1½	7	—
24	36	2¾	32	24	1⅝	7½	9¼
26	38¼	2 13/16	34½	28	1⅝	7½	9½
28	40¾	2 15/16	37	28	1⅝	7¾	9¾
30	43	3	39¼	28	1¾	8	10
32	45¼	3⅛	41½	28	1⅞	8½	10½
34	47½	3¼	43½	28	1⅞	8¾	10¾
36	50	3⅜	46	32	1⅞	9	11
38	52¼	3 7/16	48	32	1⅞	9¼	11¼
40	54½	3 9/16	50¼	36	1⅞	9½	11½
42	57	3 11/16	52¾	36	1⅞	9¾	11¾
44	59¼	3¾	55	36	2	10	12
46	61½	3⅞	57¼	40	2	10¼	12¼
48	65	4	60¾	40	2	10½	12½

Number of holes are in multiples of four, so that fittings may be made to face to any quarter. Bolt holes straddle the center lines.

Bolt holes are drilled ⅛ inch larger than nominal diameter of bolts.

(222) Template for Drilling.—

AMERICAN STANDARD FOR 125 POUNDS.

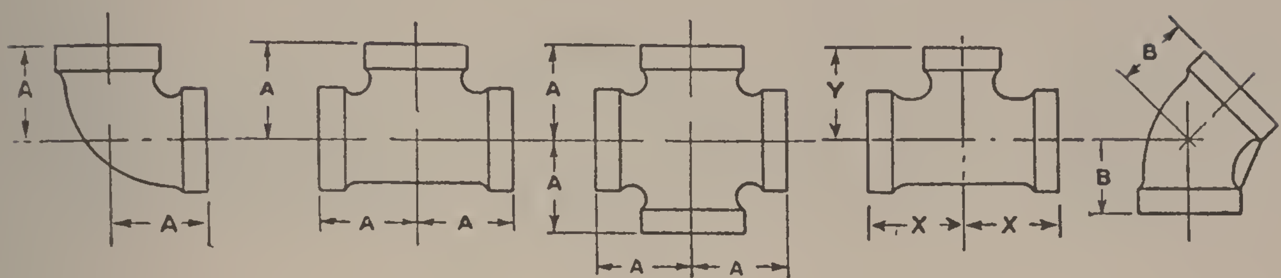
Effective January 1, 1914.

Size, inches	Diameter of flanges	Thickness of flanges	Bolt circle	Number of bolts	Size of bolts	Length of bolts	Length of studs with two nuts
1	4	7/16	3	4	7/16	1½	——
1¼	4½	½	3⅜	4	7/16	1¾	——
1½	5	9/16	3⅞	4	½	2	——
2	6	⅝	4¾	4	⅝	2¼	——
2½	7	11/16	5½	4	⅝	2¼	——
3	7½	¾	6	4	⅝	2½	——
3½	8½	13/16	7	4	⅝	2½	——
4	9	15/16	7½	8	⅝	2¾	——
4½	9¼	15/16	7¾	8	¾	3	——
5	10	15/16	8½	8	¾	3	——
6	11	1	9½	8	¾	3	——
7	12½	1 1/16	10¾	8	¾	3¼	——
8	13½	1⅛	11¾	8	¾	3¼	——
9	15	1⅛	13¼	12	¾	3¼	——
10	16	1 3/16	14¼	12	⅞	3½	——
12	19	1¼	17	12	⅞	3¾	——
14	21	1⅜	18¾	12	1	4	——
15	22¼	1⅜	20	16	1	4	——
16	23½	1 7/16	21¼	16	1	4¼	——
18	25	1 9/16	22¾	16	1⅛	4½	——
20	27½	1 11/16	25	20	1⅛	4¾	——
22	29½	1 13/16	27¼	20	1¼	5¼	——
24	32	1⅞	29½	20	1¼	5¼	——
26	34¼	2	31¾	24	1¼	5½	——
28	36½	2 1/16	34	28	1¼	5¾	——
30	38¾	2⅛	36	28	1⅜	6	——
32	41¾	2¼	38½	28	1½	6¼	——
34	43¾	2 5/16	40½	32	1½	6½	——
36	46	2⅜	42¾	32	1½	6½	——
38	48¾	2⅜	45¼	32	1⅝	6¾	8½
40	50¾	2½	47¼	36	1⅝	7	8¾

Numbers of holes are in multiples of four, so that fittings may be made to face to any quarter. Bolt holes straddle center lines.

Bolt holes are drilled ⅛ inch larger than nominal diameter of bolts.

(223) "Crane Oil" Malleable Iron S. E. Fittings.—



(Crane Co.)

DIMENSIONS.

Size, inches	A—Center to end, inches	B—Center to end, 45° ells., inches
2	2½	2
2½	3¼	2¼
3	3¾	2½
4	4½	2 13/16
6	6¼	3½
8	7¾	4 5/16
10	9¼	
12	11½	

REDUCING TEES.

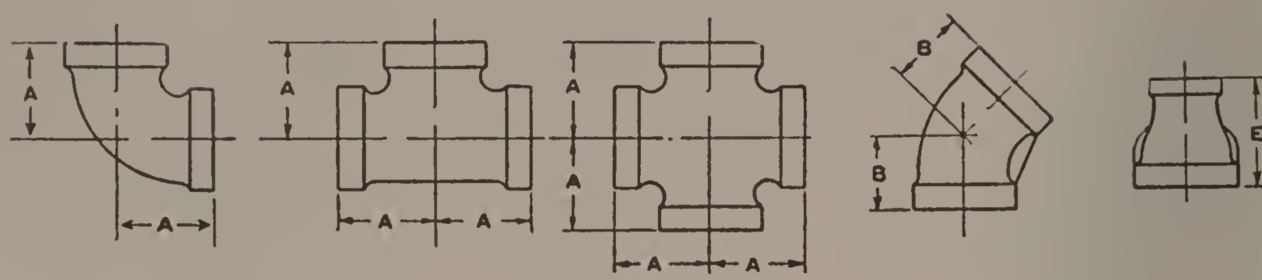
(List of Sizes).

Size, inches	X—Run, inches	Y—Outlet, inches
3x2	3 3/16	3½
4x3	4	4⅜
4x2	3 7/16	4⅛
6x4	5 3/16	6
6x3	4 11/16	5⅞
6x2	4⅛	5⅝
8x6	6¾	7½
8x4	5 11/16	7¼
8x3	5 3/16	7 3/16
10x8	8 3/16	9
10x6	7 3/16	8¾
10x4	6⅛	8½
12x10	10½	11¼
12x6	8 7/16	10 13/16

Dimensions subject to change.

12

(224) X-Hy. Malleable Iron S. E. Fittings.—



(Crane Co.)

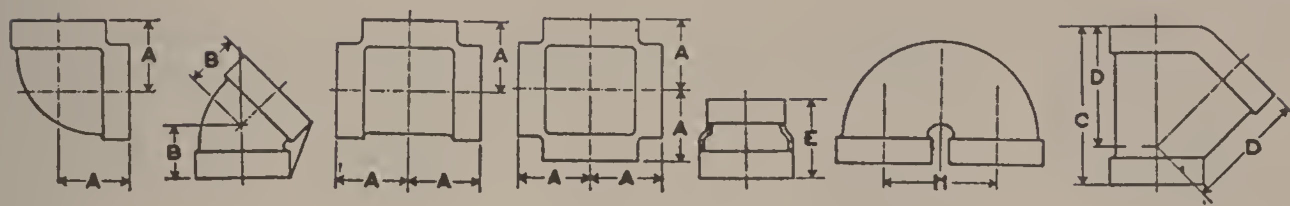
DIMENSIONS.

Size, inches	A—Center to end, inches	B—Center to end, 45° ells., inches	E—End to end reducers, inches
¼	13/16	¾	
⅜	15/16	13/16	1 7/16
½	1¼	1	1 11/16
¾	1 7/16	1⅛	1¾
1	1⅝	1 5/16	2
1¼	1⅞	1½	2⅜
1½	2⅛	1 11/16	2 11/16
2	2½	2	3 3/16
2½	3¼	2¼	3 11/16
3	3¾	2½	4 1/16
3½	4⅛	2⅝	
4	4½	2 13/16	4⅜
5	5½	3 3/16	
6	6¼	3½	5¼
8	7¾	4 5/16	6¼
10	9¼	5 3/16	7⅛
12	11½	6	8
14	12¼		
16	13¾		

These fittings have been made for twelve years, and are used in nearly all large refineries for high pressure and high temperature work around stills.

While primarily to be used on hot lines in refineries, these fittings are admirably suited for use on high pressure oil, gas and water lines, and will give better satisfaction than the extremely heavy cast iron fittings used in many fields. Having extra long thread lengths, no lip for lead or caulking recess is necessary, as tight joints are being made without difficulty. They will not stretch or crack while piping is being made up.

(225) 175 Pounds or Medium Cast Iron Screwed Fittings.—



(Crane Co.)

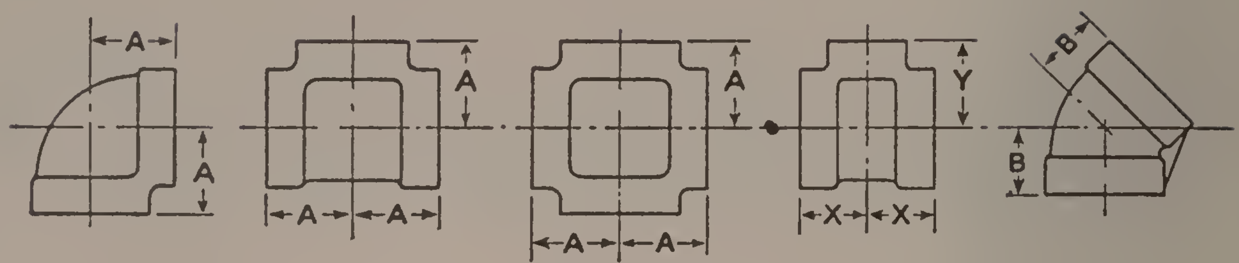
DIMENSIONS.

Size, inches	A, inches	B, inches	C, inches	D, inches	E, inches
1	1⅝	1 3/16			
1¼	1⅞	1¾			2 3/32
1½	2⅛	1 9/16	4⅞	3 13/16	2 7/32
2	2½	1 13/16	5¾	4½	2 7/16
2½	3¼	2	6¼	5 3/16	2 21/32
3	3¾	2 5/16	7⅞	6⅛	2 15/16
3½	4⅛	2½			3⅛
4	4½	2 11/16	9¾	7⅝	3⅜
6	6¼	3½	13 7/16	10⅜	4⅜
8	7½	4 9/32	16 15/16	15⅝	5¼
10	9¼	5 5/32	20 11/16	16¾	6 3/16
12	11½	5 31/32			7⅛

RETURN BENDS.

Size	H—Center to center	Size	H—Center to center
1	2⅜	2½	6
1	3	2½	7
1¼	3	3	5
1½	3¼	3	6¼
2	4	3	8
2	4½	4	6
2	6	4	7
2	6¼	4	8
2½	4½	4	12
2½	4⅞	6	10

(226) X-Hy. Cast Iron S. E. Fittings.—



(Crane Co.)

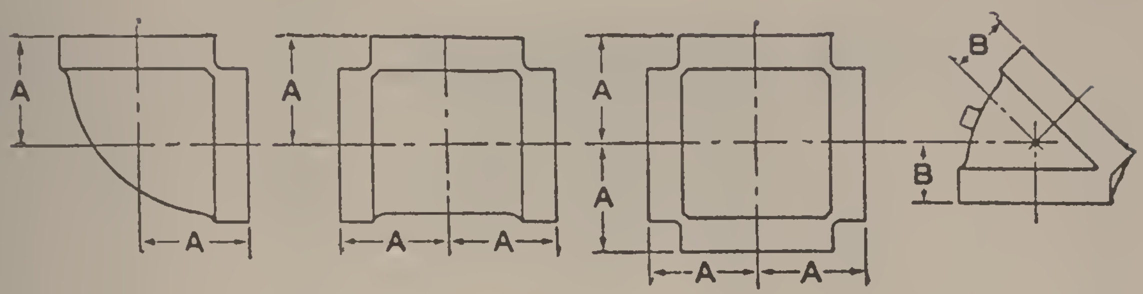
DIMENSIONS.

Size, inches	A—Center to end, inches	B—Center to end, inches
½	1¼	
¾	1 7/16	
1	1⅝	1⅜
1¼	2	1½
1½	2¼	1⅝
2	2½	1 15/16
2½	2 15/16	1¼
3	3⅜	2½
4	4⅛	2¾
6	5⅝	3¾
8	7	4¾
10	8⅝	4⅞
12	10	5½

REDUCING TEES.

Size, inches	X—Run, inches	Y—Outlet, inches	Size, inches	X—Run, inches	Y—Outlet, inches
1¼x¾	1¾	1⅞	6x4	4 9/16	5⅜
1¼x½	1 9/16	1¾	6x3	4 1/16	5¼
1½x¾	1⅞	2	6x2	3½	5
2x1½	2¼	2⅜	8x6	6	6 13/16
2x1	2	2 3/16	8x4	4 15/16	6 9/16
2½x2	2 11/16	2¾	10x8	7 9/16	8⅜
3x2½	3 1/16	3 3/16	10x6	6 9/16	8 3/16
3x2	2 13/16	3⅛	10x4	5½	7⅞
4x3	3⅝	4	12x10	9	9¾
4x2½	3 5/16	3 15/16	12x8	7 15/16	9½
4x2	3 1/16	3⅝			

(227) Cast Steel S. E. Fittings.—

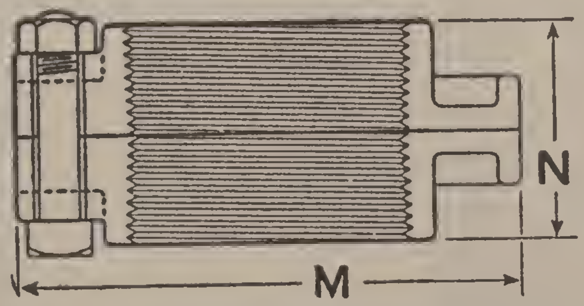


(Crane Co.)

DIMENSIONS.

Size, inches	A—Center to end, inches	B—Center to end, 45° elbows, inches
2½	3¼	2¼
3	3¾	2½
3½	4⅛	2⅝
4	4½	2 13/16
4½	5	2 15/16
5	5½	3 3/16
6	6¼	3½
8	7¾	4 5/16
10	9¼	5 3/16
12	11½	6

(228) Standard Malleable Iron Straight Thread Flange Unions.

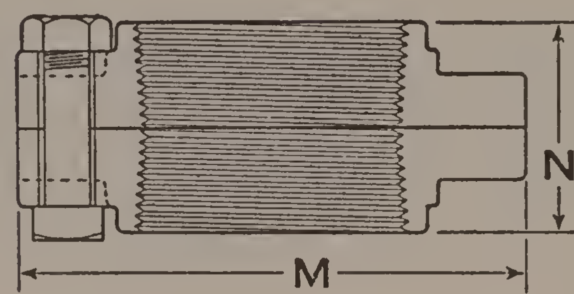


(Crane, No. 771.)

DIMENSIONS.

Size, inches	M—Outside diameter of flange	N—Height of union	Number and diameter of bolts
2	5⅛	2½	4–½
2½	6	2 13/16	4–9/16
3	7	3	4–⅝
4	8	3⅛	5–⅝
6	10½	3⅝	6–⅝
8	12¾	4	8–⅝
10	15½	4 7/16	10–¾
12	17⅞	4 13/16	12–¾

(229) X-Hy. Malleable Iron Flange Unions.—



(Crane No. 95E.)

DIMENSIONS.

Size, inches	M—Outside diameter of flange	N—Height of flange	Number and diameter of bolts
2	5⅜	2½	5–9/16
2½	6⁵/16	2 13/16	5–⅝
3	7	3	6–⅝
4	8	3⅛	7–⅝
6	11	3⅝	9–¾
8	13¼	4	10–¾
10	16	4 7/16	12–⅞
12	18⅞	4 13/16	12–1
14	21	5 1/16	12–1⅛
15	22	5 5/16	14–1⅛

(230) Standard Dimensions of Pipe.—

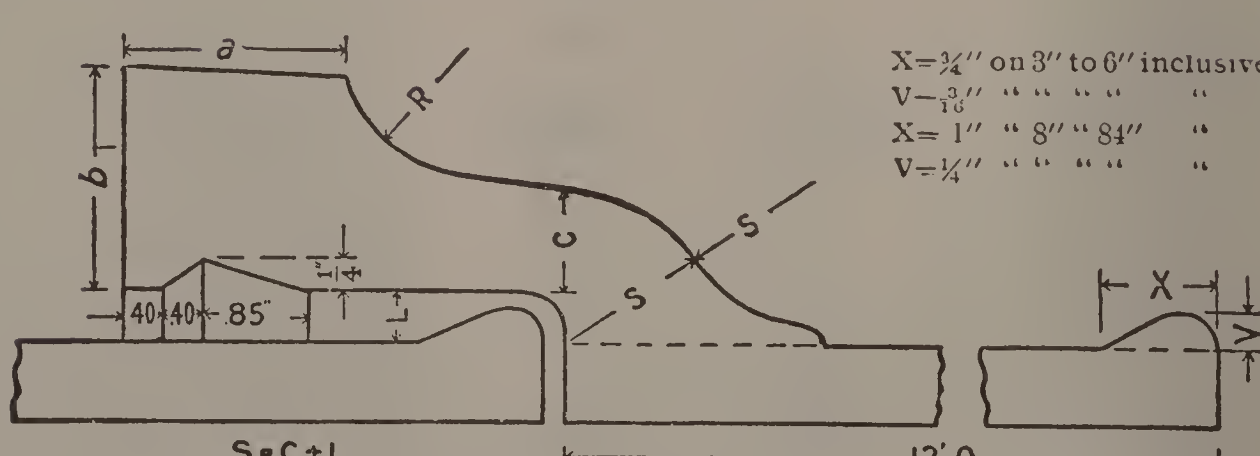


TABLE I.—(A. W. W. A. STD.)—CLASSES A, B, C, D

			Diam. of socket		Depth of socket				
Nominal diam., inches	Classes	Actual outside diam., inches	Pipe, inches	Special castings, inches	Pipe, inches	Special castings, inches	A	B	C
4	A	4.80	5.60	5.70	3.50	4.00	1.5	1.30	.65
4	B-C-D	5.00	5.80	5.70	3.50	4.00	1.5	1.30	.65
6	A	6.90	7.70	7.80	3.50	4.00	1.5	1.40	.70
6	B-C-D	7.10	7.90	7.80	3.50	4.00	1.5	1.40	.70
8	A-B	9.05	9.85	10.00	4.00	4.00	1.5	1.50	.75
8	C-D	9.30	10.10	10.00	4.00	4.00	1.5	1.50	.75
10	A-B	11.10	11.90	12.10	4.00	4.00	1.5	1.50	.75
10	C-D	11.40	12.20	12.10	4.00	4.00	1.5	1.60	.80
12	A-B	13.20	14.00	14.20	4.00	4.00	1.5	1.60	.80
12	C-D	13.50	14.30	14.20	4.00	4.00	1.5	1.70	.85
14	A-B	15.30	16.10	16.10	4.00	4.00	1.5	1.70	.85
14	C-D	15.65	16.45	16.45	4.00	4.00	1.5	1.80	.90
16	A-B	17.40	18.40	18.40	4.00	4.00	1.75	1.80	.90
16	C-D	17.80	18.80	18.80	4.00	4.00	1.75	1.90	1.00
18	A-B	19.50	20.50	20.50	4.00	4.00	1.75	1.90	.95
18	C-D	19.92	20.92	20.92	4.00	4.00	1.75	2.10	1.05
20	A-B	21.60	22.60	22.60	4.00	4.00	1.75	2.00	1.00
20	C-D	22.06	23.06	23.06	4.00	4.00	1.15	2.30	1.15
24	A-B	25.80	26.80	26.80	4.00	4.00	2.00	2.10	1.05
24	C-D	26.32	27.32	27.32	4.00	4.00	2.00	2.50	1.25
30	A	31.74	32.74	32.74	4.50	4.50	2.00	2.30	1.15
30	B	32.00	33.00	33.00	4.50	4.50	2.00	2.30	1.15
30	C	32.40	33.40	33.40	4.50	4.50	2.00	2.60	1.32
30	D	32.74	33.74	33.74	4.50	4.50	2.00	3.00	1.50
36	A	37.96	38.96	38.96	4.50	4.50	2.00	2.50	1.25
36	B	38.30	39.30	39.30	4.50	4.50	2.00	2.80	1.40
36	C	38.70	39.70	39.70	4.50	4.50	2.00	3.10	1.60
36	D	39.16	40.16	40.16	4.50	4.50	2.00	3.40	1.80
42	A	44.20	45.20	45.20	5.00	5.00	2.00	2.80	1.40
42	B	44.50	45.50	45.50	5.00	5.00	2.00	3.00	1.50
42	C	45.10	46.10	46.10	5.00	5.00	2.00	3.40	1.75
42	D	45.58	46.58	46.58	5.00	5.00	2.00	3.80	1.95
48	A	50.50	51.50	51.50	5.00	5.00	2.00	3.00	1.50
48	B	50.80	51.80	51.80	5.00	5.00	2.00	3.30	1.65
48	C	51.40	52.40	52.40	5.00	5.00	2.00	3.80	1.95
48	D	51.98	52.98	52.98	5.00	5.00	2.00	4.20	2.20
54	A	56.66	57.66	57.66	5.50	5.50	2.25	3.20	1.60
54	B	57.10	58.10	58.10	5.50	5.50	2.25	3.60	1.80
54	C	57.80	58.80	58.80	5.50	5.50	2.25	4.00	2.15
54	D	58.40	59.40	59.40	5.50	5.50	2.25	4.40	2.45
60	A	62.80	63.80	63.80	5.50	5.50	2.25	3.40	1.70
60	B	63.40	64.40	64.40	5.50	5.50	2.25	3.70	1.90
60	C	64.20	65.20	65.20	5.50	5.50	2.25	4.20	2.25
60	D	64.82	65.82	65.82	5.50	5.50	2.25	4.70	2.60
72	A	75.34	76.34	76.34	5.50	5.50	2.25	3.80	1.87
72	B	76.00	77.00	77.00	5.50	5.50	2.25	4.20	2.20
72	C	76.88	77.88	77.88	5.50	5.50	2.25	4.60	2.64
84	A	87.54	88.54	88.54	5.50	5.50	2.50	4.10	2.10
84	B	88.54	89.54	89.54	5.50	5.50	2.50	4.50	2.60

(231) Standard Thickness and Weights of Cast Iron Pipe.—

TABLE II.—(A. W. W. A. STD.) CLASSES A, B, C, D.

Nominal inside diameter, inches	Class A 100-Feet head, 43 pounds pressure			Class B 200-Feet head, 86 pounds pressure			Class C 300-Feet head, 130 pounds pressure			Class D 400-Feet head, 173 pounds pressure			Nominal inside diameter, inches
	Thickness, inches	Weight per Foot	Weight per Length	Thickness, inches	Weight per Foot	Weight per Length	Thickness, inches	Weight per Foot	Weight per Length	Thickness, inches	Weight per Foot	Weight per Length	
4	.42	20.0	240	.45	21.7	260	.48	23.3	280	.52	25.0	300	4
6	.44	30.8	370	.48	33.3	400	.51	35.8	430	.55	38.3	460	6
8	.46	42.9	515	.51	47.5	570	.56	52.1	625	.60	55.8	670	8
10	.50	57.1	685	.57	63.8	765	.62	70.8	850	.68	76.7	920	10
12	.54	72.5	870	.62	82.1	985	.68	91.7	1100	.75	100.0	1200	12
14	.57	89.6	1075	.66	102.5	1230	.74	116.7	1400	.82	129.2	1550	14
16	.60	108.3	1300	.70	125.0	1500	.80	143.8	1725	.89	158.3	1900	16
18	.64	129.2	1550	.75	150.0	1800	.87	175.0	2100	.96	191.7	2300	18
20	.67	150.0	1800	.80	175.0	2100	.92	208.3	2500	1.03	229.2	2750	20
24	.76	204.2	2450	.89	233.3	2800	1.04	279.2	3350	1.16	306.7	3680	24
30	.88	291.7	3500	1.03	333.3	4000	1.20	400.0	4800	1.37	450.0	5400	30
36	.99	391.7	4700	1.15	454.2	5450	1.36	545.8	6550	1.58	625.0	7500	36
42	1.10	512.5	6150	1.28	591.7	7100	1.54	716.7	8600	1.78	825.0	9900	42
48	1.26	666.7	8000	1.42	750.0	9000	1.71	908.3	10900	1.96	1050.0	12600	48
54	1.35	800.0	9600	1.55	933.3	11200	1.90	1141.7	13700	2.23	1341.7	16100	54
60	1.39	916.7	11000	1.67	1104.2	13250	2.00	1341.7	16100	2.38	1583.3	19000	60
72	1.62	1283.4	15400	1.95	1545.8	18550	2.39	1904.2	22850	—	—	—	72
84	1.72	1633.4	19600	2.22	2104.2	25250	—	—	—	—	—	—	84

The above weights are per length to lay 12 feet, including standard sockets; proportionate allowance to be made for any variation.

Chart Gives Cast Iron Pipe Costs.

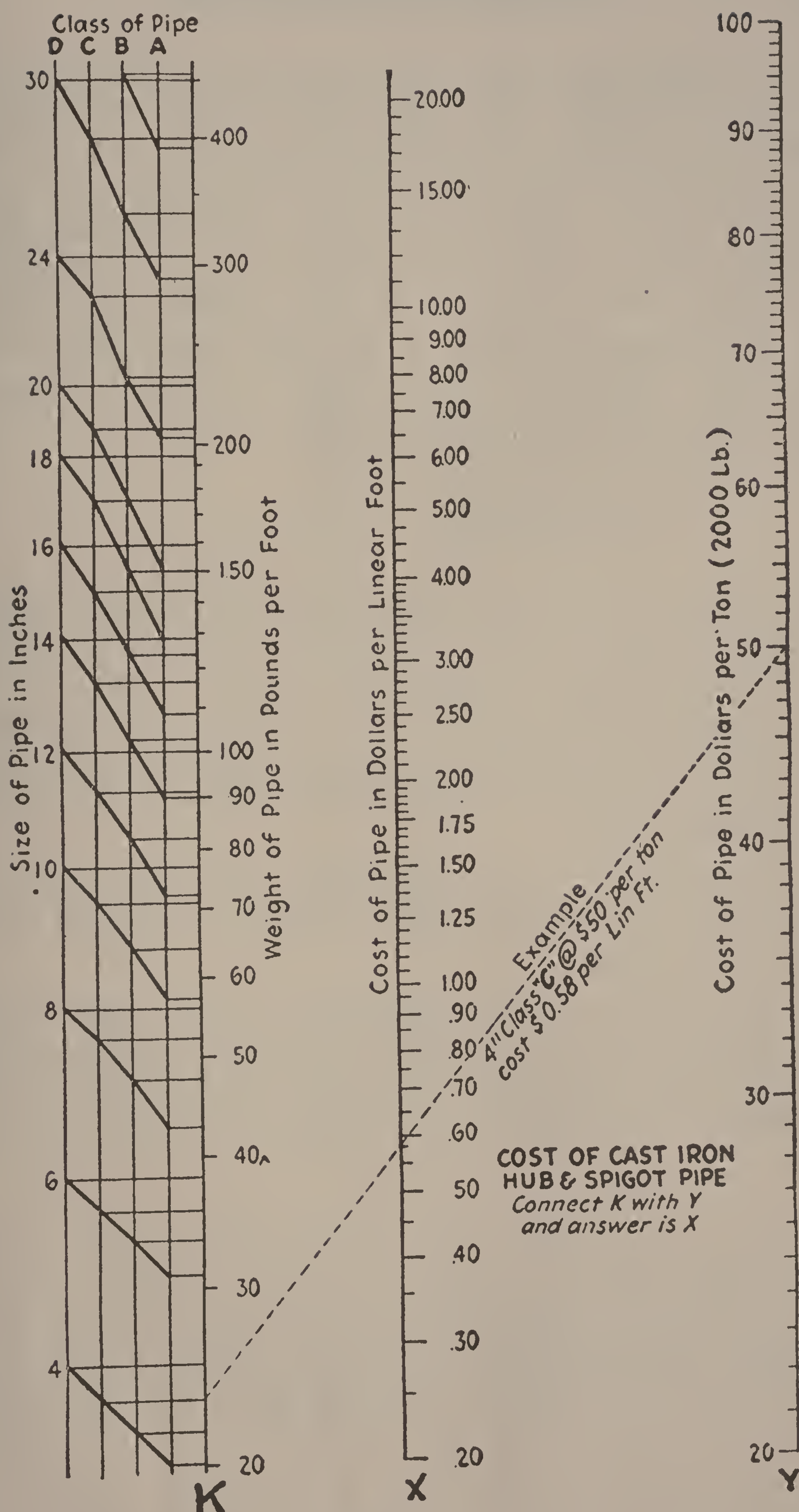


Fig. 17.

The accompanying chart, Fig. 17, for determining the linear-foot cost of cast-iron water pipe, will be found convenient and useful in determining unit costs for any size and class of American Water Works Association standard hub and spigot pipe at any price per ton. Special advantage is offered by the chart to the field engineer and to the contractor; who, by remembering the current price of pipe per ton, may determine immediately and with sufficient accuracy by this chart the required results. Connect the weight per linear of pipe of any desired class, as shown on line K, with the current price on line Y, and read the result on line X, as shown by example.

The Elasticity of Pipe Bends.

This subject is of great importance in the oil-refining industry, and especially so in cracking plants where temperatures from 750 to 1,000 deg. F. may be employed at pressures from 100 pounds to over 1,000 pounds per square inch. Since a failure of a pipe or joint under these conditions is almost certain to cause a dangerous fire, it is of prime importance that expansion be fully considered in designing.

To find the load on an anchor, both charts should be used in conjunction so that the allowable unit stress in the pipe will not exceed safe limits.

It will be noticed upon comparing the results given by these charts against other design tables that quarter-bends in particular have little expansion value, and that the unit stress in the pipe wall must be very high for the expansion value allowed in some cases.

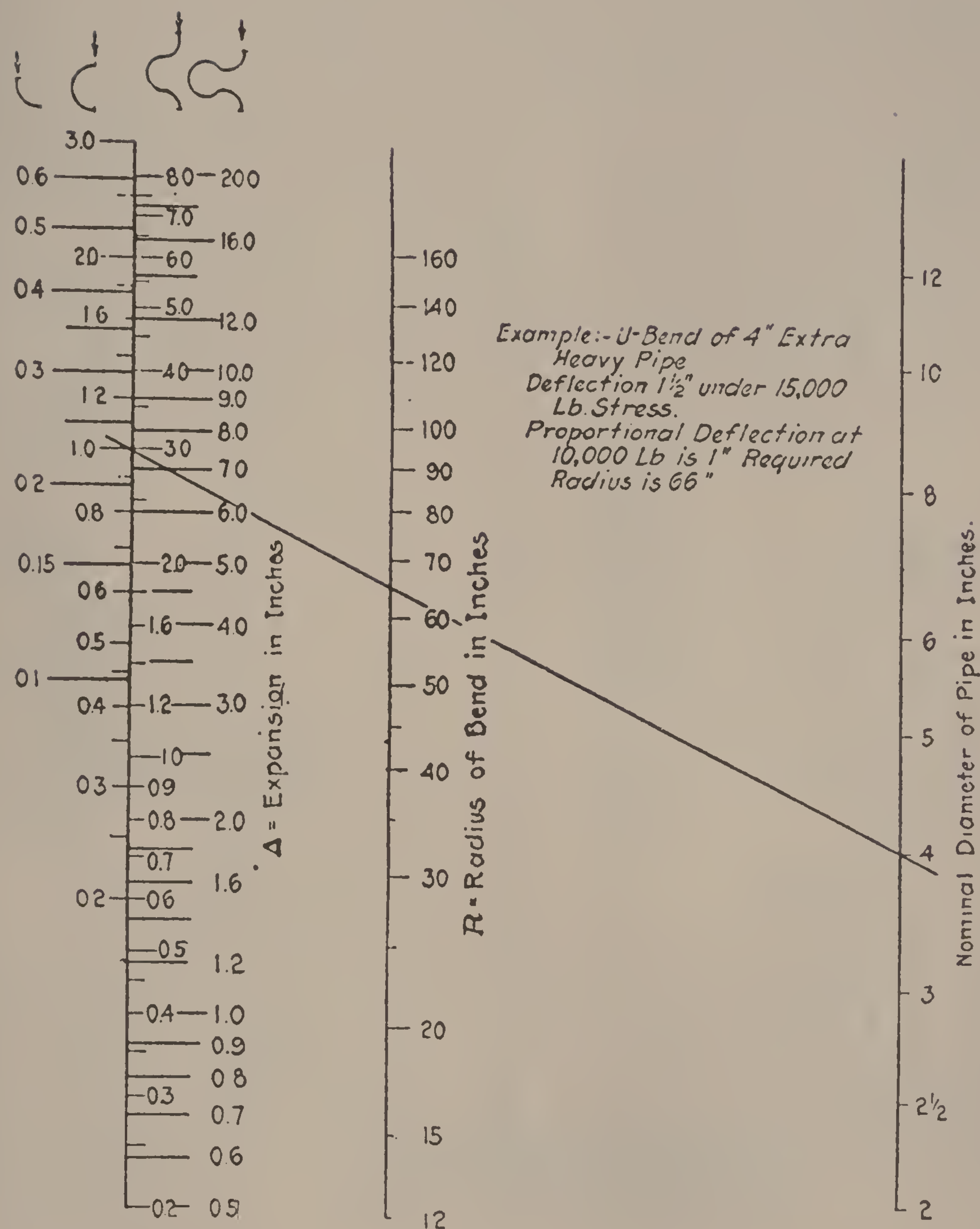


Fig. 18.

Expansion Bends. Allowable Expansion for Unit Stress of 10,000 Lb. per Sq. In.

(This chart gives the expansion cared for by various types of bends at a unit stress of 10,000 lb. per sq. in. At any other stress expansion found should be multiplied by $S/10{,}000$. Formula used: $S = CD\,\Delta\,E/R^2$, where S = unit stress, D = outside diameter, Δ = expansion, E = modulus of elasticity, R = radius of bend, and C = constant depending on type and having the following values: Quarter-bend, 1.404; plain U-bend, 0.318; expansion U-bend, 0.106; double-offset expansion U-bend, 0.0427.)

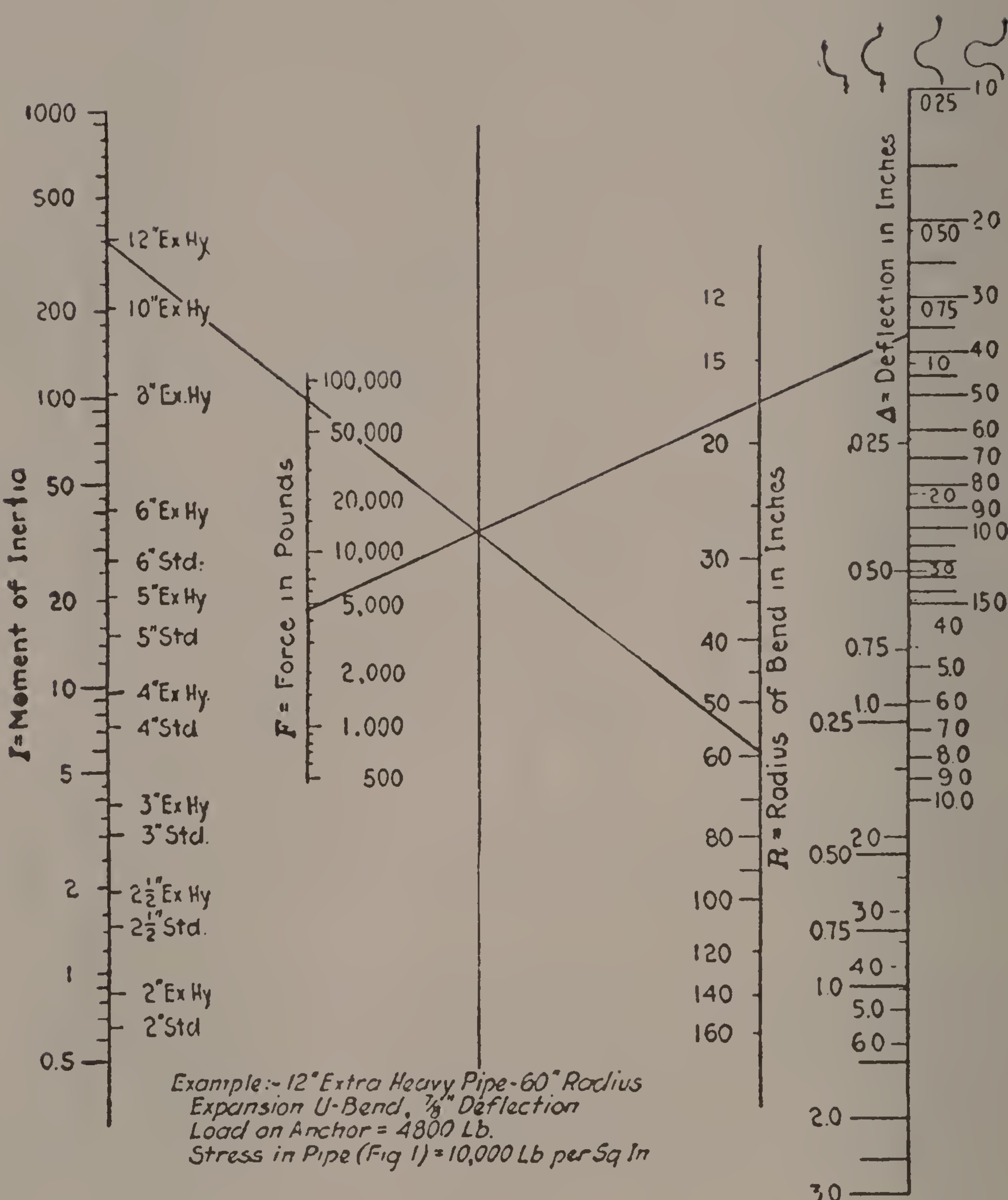


Fig. 19.

EXPANSION BENDS. FORCE AGAINST ANCHOR FOR VARIOUS TYPES OF BENDS.

(This chart gives the force against an anchor for any deflection of various types of pipe bends. For other sizes of pipe than those given, find moment of inertia $I = 0.393\, t(D^3 + t^2D)$, where D = mean diameter. Formula used: $\Delta = FR^2/EI$.)

(232) Concrete Tanks Cheaper than Steel.—In figuring the cost of a permanent oil storage installation, one should take into account every item in connection with such storage, such as the original cost of installation, foundations, ground-space, depreciation, fire-risk, loss by evaporation, maintenance, etc.

One of the largest steel manufacturers of the Pittsburgh district figures the life of an ordinary steel tank at ten years when buried, or thirty years, with proper maintenance, above ground.

Therefore, comparing the steel tank above ground with a concrete tank under ground we have the following for steel as against concrete tanks. Costs per gallon are based on a 30,000-gallon tank for the 1918 market:

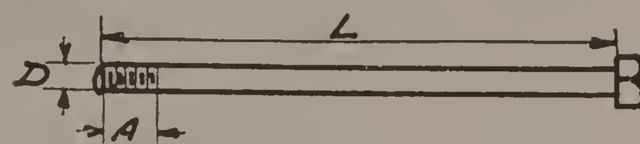
	Steel	Concrete
Tank erected	.085	.09
Foundation	.005	.00
Ground space	variable	.00
Depreciation	.085	.00
Insurance increase	.04	.00
Maintenance	.03	.00
Additional heating	.045	.00
Loss from evaporation	.15	.00
Cost per 30-year gallon	.44	.09

In the above the life of a concrete tank is taken at thirty years. However it is not *fair* to limit its life to thirty years, but rather to a sixty or one hundred-*year span,* in which it is evident that the cost of a concrete tank is still 9 cents, against that of eighty-eight cents to $1.32 per gallon for a steel tank, and so on indefinitely.

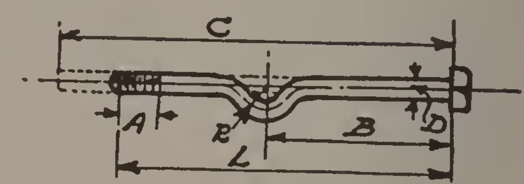
(233) Specific Heats.—

Alcohol	=	.700
Benzine	=	.450
Crude oil (Penna.)	=	.500
Crude oil (Cal.)	=	.400
Crude oil (Ohio)	=	.490
Ether	=	.503
Gasoline	=	.510
Kerosene	=	.500
Naphtha	=	.300

(234) Anchor Bolts and Plates for Building Columns, Pump Foundations, Etc.—

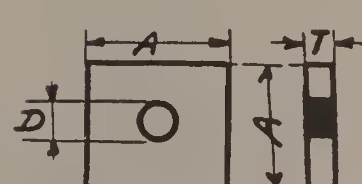


D	L	A	WEIGHT OF 10 PIECES.
1/2"	9"	2"	6.4 lbs
5/8"	10 1/2"	2 1/4"	11.9
3/4"	15"	2 1/2"	23.5
7/8"	19 1/2"	2 3/4"	40.7
1"	24"	3"	64.7
1 1/8"	28 1/2"	3 1/4"	96.3
1 1/4"	33"	3 1/2"	136.1
1 1/2"	42"	4"	248.5
1 3/4"	51"	4 1/2"	407.3
2"	60"	5"	605.2



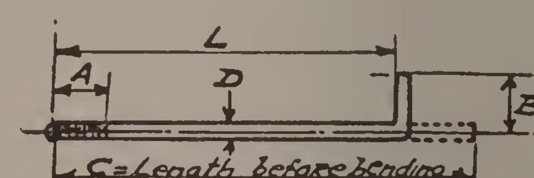
D	L	R	A	B	C	WEIGHT OF 10 PCS.
1/2"	9"	7/8"	2"	3 1/2"	9 5/8"	6.7#
5/8"	10 1/2"	1"	2 1/4"	4 1/8"	11 3/8"	12.6#
3/4"	15"	1 1/4"	2 1/2"	6 1/4"	16 1/8"	24.9#
7/8"	19 1/2"	1 3/8"	2 3/4"	8 3/8"	20 5/8"	42.7#
1"	24"	1 5/8"	3"	10 1/2"	25 1/2"	69.1#
1 1/8"	28 1/2"	1 3/4"	3 1/4"	12 5/8"	30"	100.6#
1 1/4"	33"	1 7/8"	3 1/2"	14 3/4"	34 5/8"	142.5#
1 1/2"	42"	2 1/4"	4"	19"	44"	258.5#
1 3/4"	51"	2 5/8"	4 1/2"	23 1/4"	53 1/8"	422.8#
2"	60"	3"	5"	27 1/2"	62 3/4"	649.1#

"Weights do not include nuts or washers."



A	T	D	SIZE OF BOLTS.		AREA SQ. IN.	WT. OF 10 PIECES.
3"	3/16"	11/16"	1/2"	5/8"	8.63	4.6#
4"	"	"	"	"	15.63	8.3#
5"	1/4"	13/16"	5/8"	3/4"	24.48	17.3#
6"	"	1"	3/4"	7/8"	35.21	24.9#
8"	3/8"	1 1/8"	7/8"	1"	63.00	66.9#
10"	"	1 1/4"	1"	1 1/8"	98.77	104.9#
12"	1/2"	1 3/8"	1 1/4"	1 1/2"	141.93	201.1#

Square anchor plates (mild steel).



D	L	A	B	C	WEIGHT 10 PIECES.
1/2"	9"	2"	2"	11 1/4"	6.2#
5/8"	10 1/2"	2 1/4"	2 1/4"	13 1/8"	11.4#
3/4"	15"	2 1/2"	2 1/2"	18"	22.5#
7/8"	19 1/2"	2 3/4"	2 3/4"	22 3/4"	38.7#
1"	24"	3"	3"	27 1/2"	61.2#
1 1/8"	28 1/2"	3 1/4"	3 1/4"	32 3/4"	91.2#
1 1/4"	33"	3 1/2"	3 1/2"	37 1/8"	146.3#
1 1/2"	42"	4"	4"	46 3/4"	234.1#
1 3/4"	51"	4 1/2"	4 1/2"	56 1/2"	385.04#
2"	60"	5"	5"	66 1/8"	588.5#

Weights do not include nuts or washers.

Fig. 20.

(235) To Make One Cubic Yard of Rammed Concrete it will Require.—

Using 1" stone and under (Dust screened out)	Using 2½" stone and under (Dust screened out)
1-1½-3 Concrete	1-1½-3 Concrete
1.85 Bbls. of cement	1.90 Bbls. of cement
0.42 Cu. yds. of sand	0.43 Cu. yds. of sand
0.84 Cu. yds. of stone	0.87 Cu. yds. of stone
1-2-4 Concrete	1-2-4 Concrete
1.46 Bbls. of cement	1.48 Bbls. of cement
0.44 Cu. yds. of sand	0.45 Cu. yds. of sand
0.89 Cu. yds. of stone	0.90 Cu. yds. of stone
1-2½-4 Concrete	1-2½-4 Concrete
1.35 Bbls. of cement	1.38 Bbls. of cement
0.52 Cu. yds. of sand	0.53 Cu. yds. of sand
0.82 Cu. yds. of stone	0.84 Cu. yds. of stone
1-2½-4½ Concrete	1-2½-4½ Concrete
1.27 Bbls. of cement	1.29 Bbls. of cement
0.48 Cu. yds. of sand	0.49 Cu. yds. of sand
0.87 Cu. yds. of stone	0.88 Cu. yds. of stone
1-2-5 Concrete	1-2-5 Concrete
1.27 Bbls. of cement	1.29 Bbls. of cement
0.39 Cu. yds. of sand	0.39 Cu. yds. of sand
0.97 Cu. yds. of stone	0.98 Cu. yds. of stone
1-2½-5 Concrete	1-2½-5 Concrete
1.19 Bbls. of cement	1.21 Bbls. of cement
0.46 Cu. yds. of sand	0.46 Cu. yds. of sand
0.91 Cu. yds. of stone	0.92 Cu. yds. of stone
1-3-5 Concrete	1-3-5 Concrete
1.11 Bbls. of cement	1.14 Bbls. of cement
0.51 Cu. yds. of sand	0.52 Cu. yds. of sand
0.85 Cu. yds. of stone	0.87 Cu. yds. of stone
1-3½-5½ Concrete	1-3½-5½ Concrete
1.00 Bbls. of cement	1.02 Bbls. of cement
0.53 Cu. yds. of sand	0.54 Cu. yds. of sand
0.84 Cu. yds. of stone	0.85 Cu. yds. of stone
1-3-6 Concrete	1-3-6 Concrete
1.01 Bbls. of cement	1.02 Bbls. of cement
0.46 Cu. yds. of sand	0.47 Cu. yds. of sand
0.92 Cu. yds. of stone	0.93 Cu. yds. of stone

Using 1" stone and under
(Dust screened out)

1-3½-6 Concrete
- 0.95 Bbls. of cement
- 0.50 Cu. yds. of sand
- 0.87 Cu. yds. of stone

1-3-7 Concrete
- 0.91 Bbls. of cement
- 0.42 Cu. yds. of sand
- 0.97 Cu. yds. of stone

1-3½-7 Concrete
- 0.87 Bbls. of cement
- 0.47 Cu. yds. of sand
- 0.93 Cu. yds. of stone

1-4-7 Concrete
- 0.83 Bbls. of cement
- 0.51 Cu. yds. of sand
- 0.89 Cu. yds. of stone

1-4-7½ Concrete
- 0.80 Bbls. of cement
- 0.49 Cu. yds. of sand
- 0.91 Cu. yds. of stone

1-4-8 Concrete
- 0.77 Bbls. of cement
- 0.47 Cu. yds. of sand
- 0.93 Cu. yds. of stone

Using 2½" stone and under
(Dust screened out)

1-3½-6 Concrete
- 0.97 Bbls. of cement
- 0.51 Cu. yds. of sand
- 0.89 Cu. yds. of stone

1-3-7 Concrete
- 0.92 Bbls. of cement
- 0.42 Cu. yds. of sand
- 0.98 Cu. yds. of stone

1-3½-7 Concrete
- 0.89 Bbls. of cement
- 0.47 Cu. yds. of sand
- 0.95 Cu. yds. of stone

1-4-7 Concrete
- 0.84 Bbls. of cement
- 0.51 Cu. yds. of sand
- 0.90 Cu. yds. of stone

1-4-7½ Concrete
- 0.81 Bbls. of cement
- 0.50 Cu. yds. of sand
- 0.93 Cu. yds. of stone

1-4-8 Concrete
- 0.78 Bbls. of cement
- 0.48 Cu. yds. of sand
- 0.95 Cu. yds. of stone

To Make One Cubic Yard of Rammed Concrete it Will Require

Using 2½" stone
(Most small stone screened out)

1-1½-3 Concrete
- 1.96 Bbls. of cement
- 0.45 Cu. yds. of sand
- 0.89 Cu. yds. of stone

1-2-4 Concrete
- 1.53 Bbls. of cement
- 0.47 Cu. yds. of sand
- 0.93 Cu. yds. of stone

1-2½-4 Concrete
- 1.42 Bbls. of cement
- 0.54 Cu. yds. of sand
- 0.87 Cu. yds. of stone

1-2½-4½ Concrete
- 1.33 Bbls. of cement
- 0.51 Cu. yds. of sand
- 0.91 Cu. yds. of stone

Using ¾" gravel and under
(Sand screened out)

1-1½-3 Concrete
- 1.71 Bbls. of cement
- 0.39 Cu. yds. of sand
- 0.78 Cu. yds. of stone

1-2-4 Concrete
- 1.34 Bbls. of cement
- 0.41 Cu. yds. of sand
- 0.81 Cu. yds. of stone

1-2½-4 Concrete
- 1.24 Bbls. of cement
- 0.47 Cu. yds. of sand
- 0.75 Cu. yds. of stone

1-2½-4½ Concrete
- 1.16 Bbls. of cement
- 0.44 Cu. yds. of sand
- 0.80 Cu. yds. of stone

Using 2½″ stone
(Most small stone screened out)

1-2-5 Concrete
1.33 Bbls. of cement
0.39 Cu. yds. of sand
1.03 Cu. yds. of stone

1-2½-5 Concrete
1.26 Bbls. of cement
0.48 Cu. yds. of sand
0.96 Cu. yds. of stone

1-3-5 Concrete
1.17 Bbls. of cement
0.54 Cu. yds. of sand
0.89 Cu. yds. of stone

1-3½-5½ Concrete
1.06 Bbls. of cement
0.56 Cu. yds. of sand
0.89 Cu. yds. of stone

1-3-6 Concrete
1.06 Bbls. of cement
0.48 Cu. yds. of sand
0.97 Cu. yds. of stone

1-3½-6 Concrete
1.00 Bbls. of cement
0.53 Cu. yds. of sand
0.92 Cu. yds. of stone

1-3-7 Concrete
0.94 Bbls. of cement
0.42 Cu. yds. of sand
1.05 Cu. yds. of stone

1-3½-7 Concrete
0.91 Bbls. of cement
0.49 Cu. yds. of sand
0.98 Cu. yds. of stone

1-4-7 Concrete
0.87 Bbls. of cement
0.53 Cu. yds. of sand
0.93 Cu. yds. of stone

1-4-7½ Concrete
0.84 Bbls. of cement
0.51 Cu. yds. of sand
0.96 Cu. yds. of stone

1-4-8 Concrete
0.81 Bbls. of cement
0.49 Cu. yds. of sand
0.98 Cu. yds. of stone

Using ¾″ gravel and under
(Sand screened out)

1-2-5 Concrete
1.17 Bbls. of cement
0.36 Cu. yds. of sand
0.89 Cu. yds. of stone

1-2½-5 Concrete
1.10 Bbls. of cement
0.42 Cu. yds. of sand
0.83 Cu. yds. of stone

1-3-5 Concrete
1.03 Bbls. of cement
0.47 Cu. yds. of sand
0.78 Cu. yds. of stone

1-3½-5½ Concrete
0.92 Bbls. of cement
0.48 Cu. yds. of sand
0.78 Cu. yds. of stone

1-3-6 Concrete
0.92 Bbls. of cement
0.42 Cu. yds. of sand
0.84 Cu. yds. of stone

1-3½-6 Concrete
0.88 Bbls. of cement
0.46 Cu. yds. of sand
0.80 Cu. yds. of stone

1-3-7 Concrete
0.84 Bbls. of cement
0.38 Cu. yds. of sand
0.89 Cu. yds. of stone

1-3½-7 Concrete
0.80 Bbls. of cement
0.43 Cu. yds. of sand
0.85 Cu. yds. of stone

1-4-7 Concrete
0.77 Bbls. of cement
0.47 Cu. yds. of sand
0.81 Cu. yds. of stone

1-4-7½ Concrete
0.73 Bbls. of cement
0.44 Cu. yds. of sand
0.83 Cu. yds. of stone

1-4-8 Concrete
0.71 Bbls. of cement
0.43 Cu. yds. of sand
0.86 Cu. yds. of stone

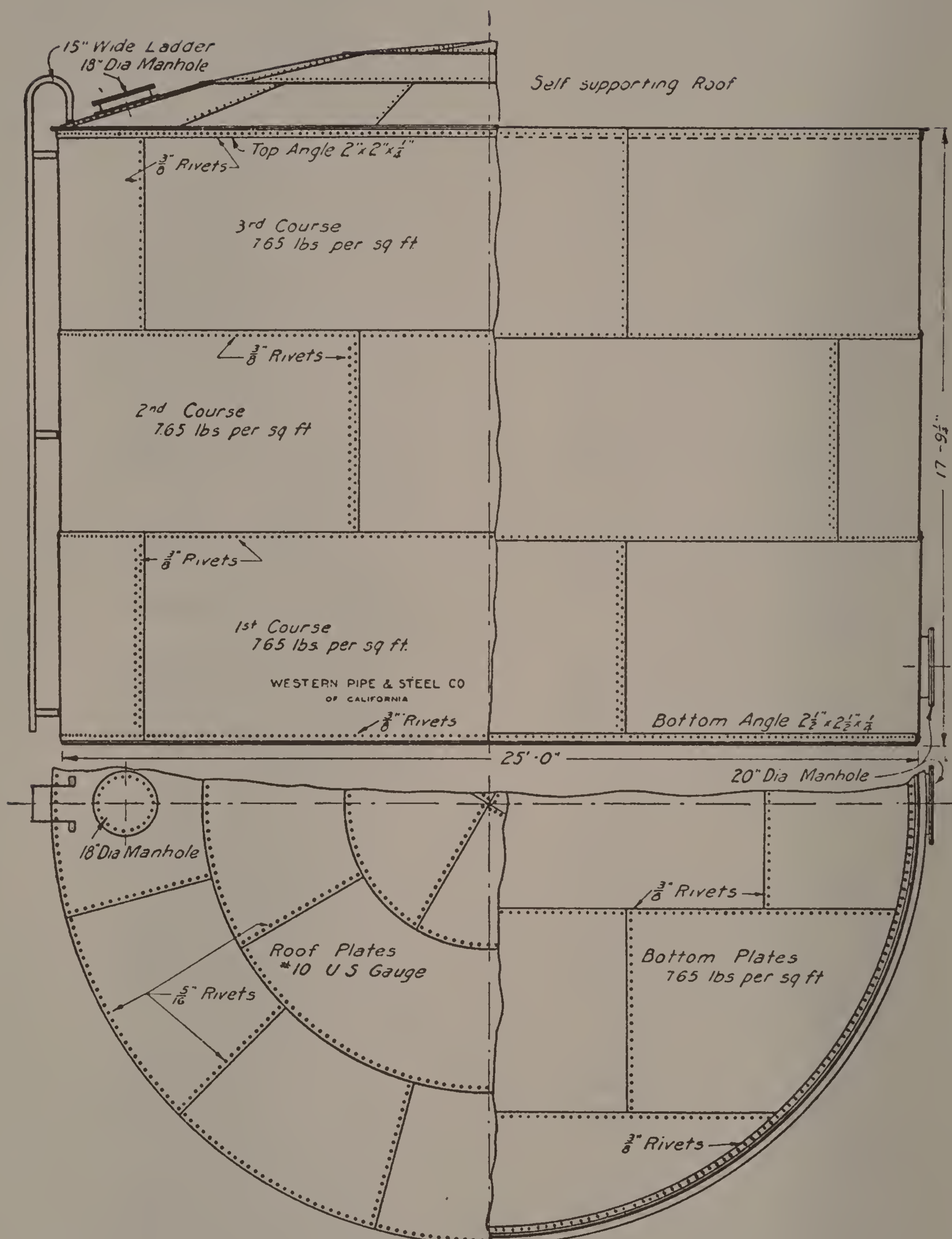


Fig. 21.
Standard 1,500-barrel tank.

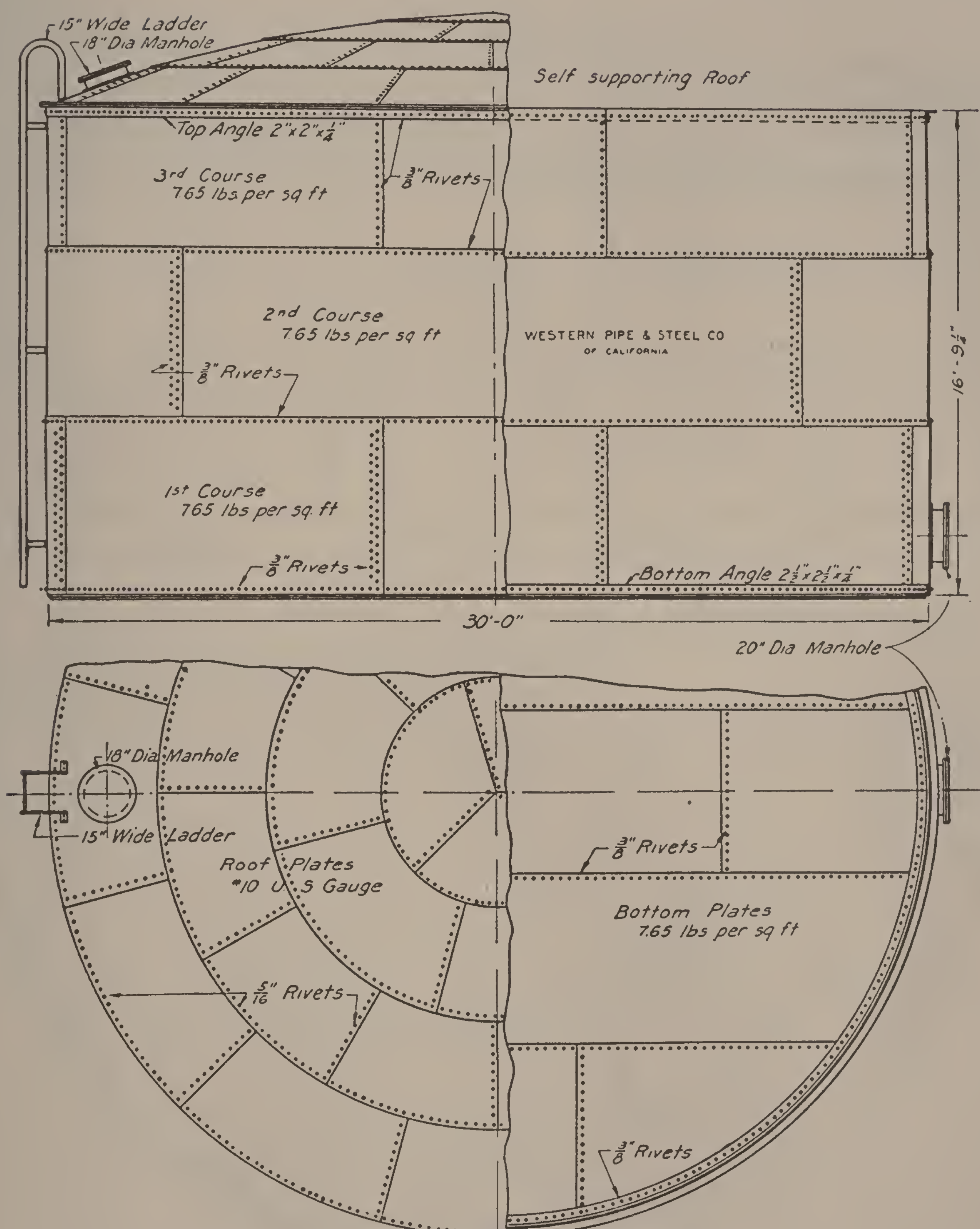


Fig. 22.
Standard 2,000-barrel tank.

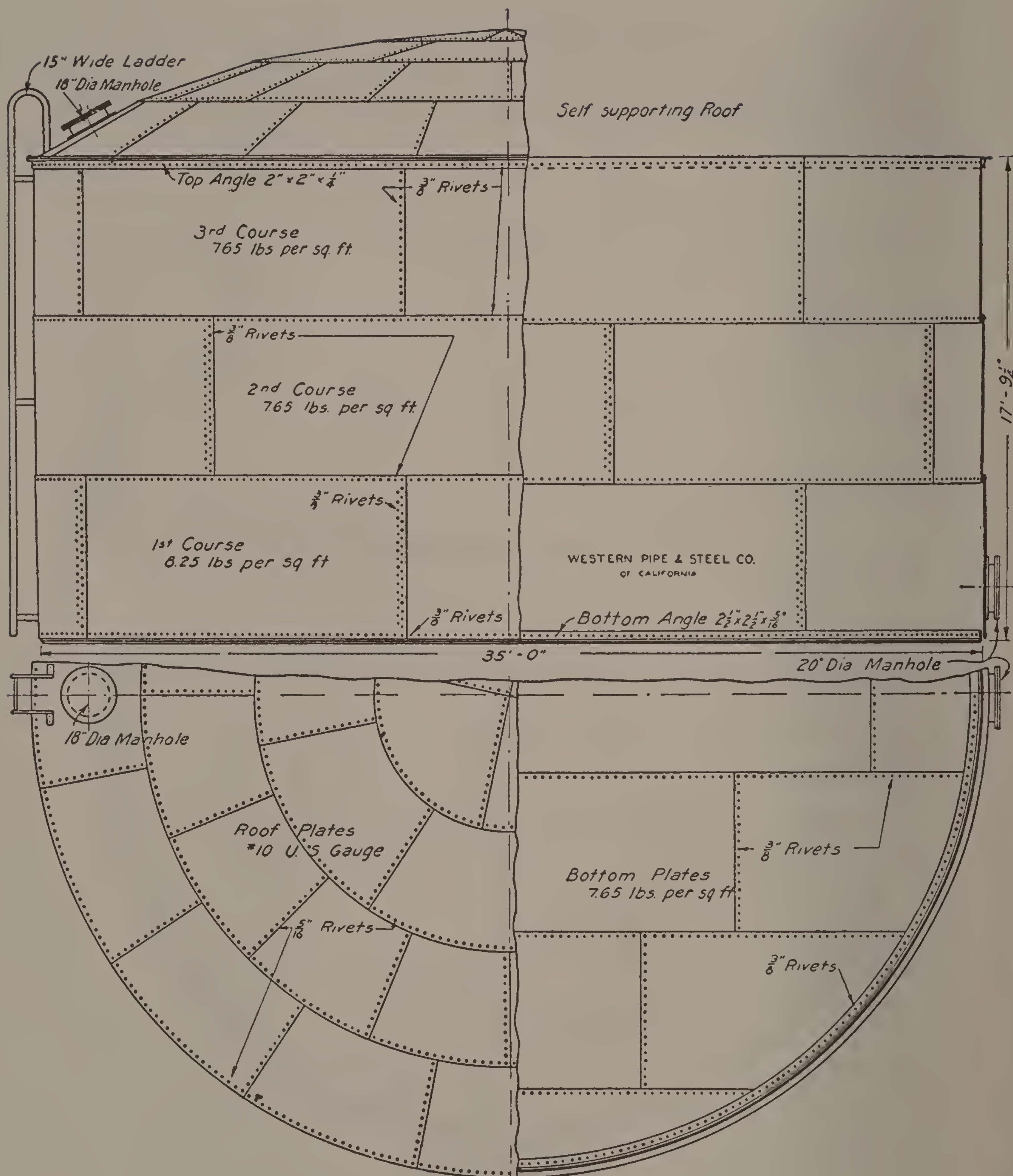


Fig. 23.
Standard 3,000-barrel tank.

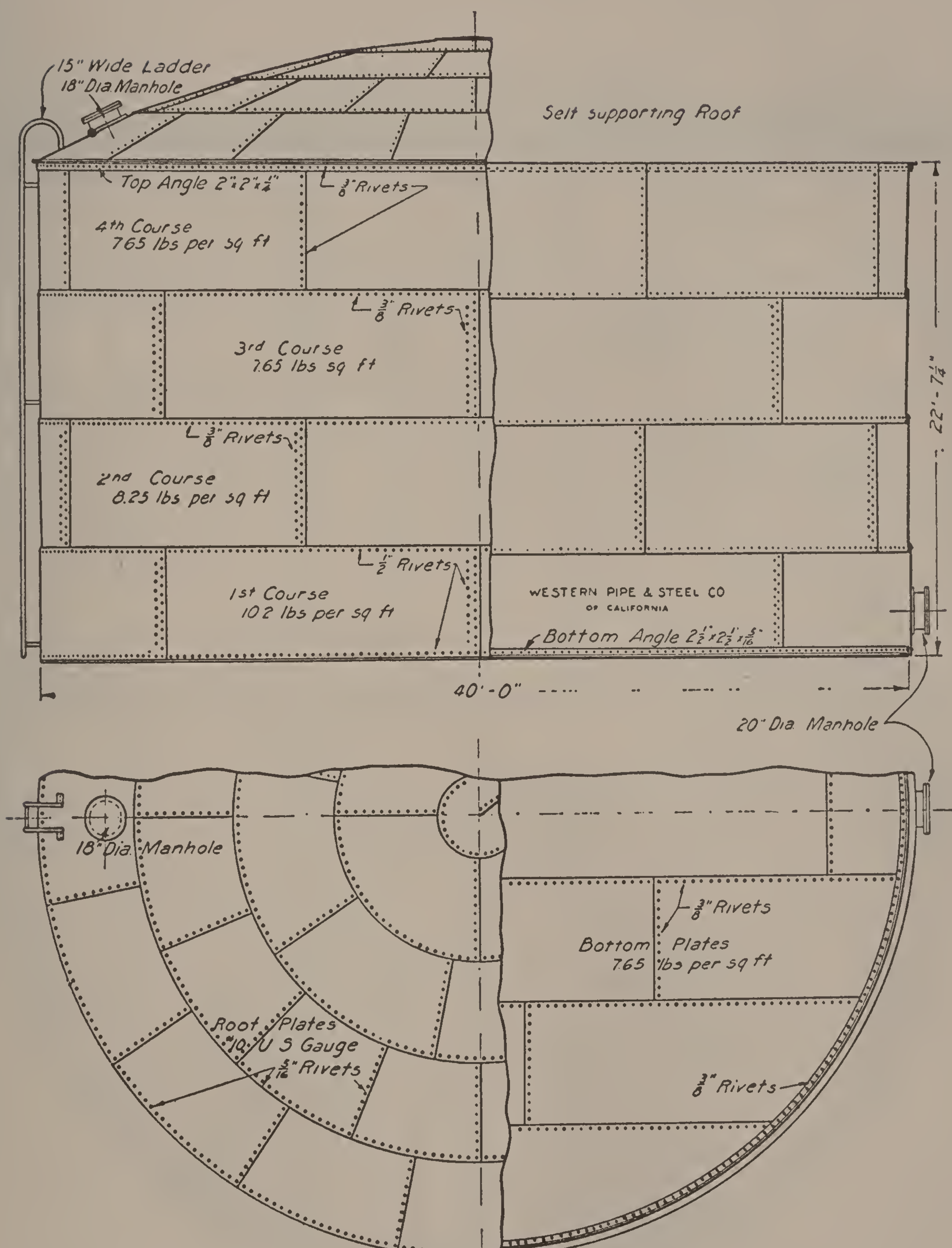


Fig. 24.
Standard 5,000-barrel tank.

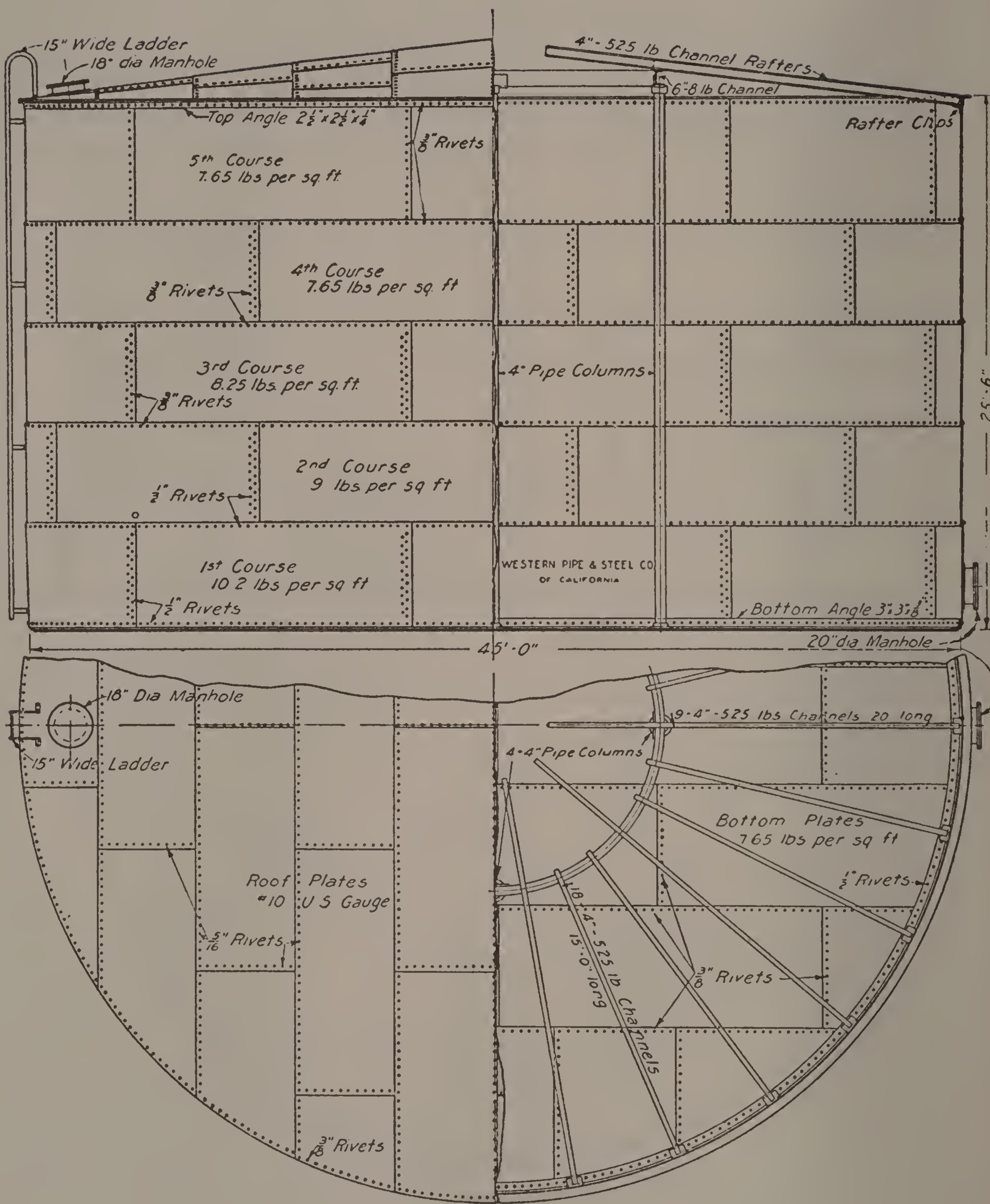


Fig. 25.
Standard 7,000-barrel tank.

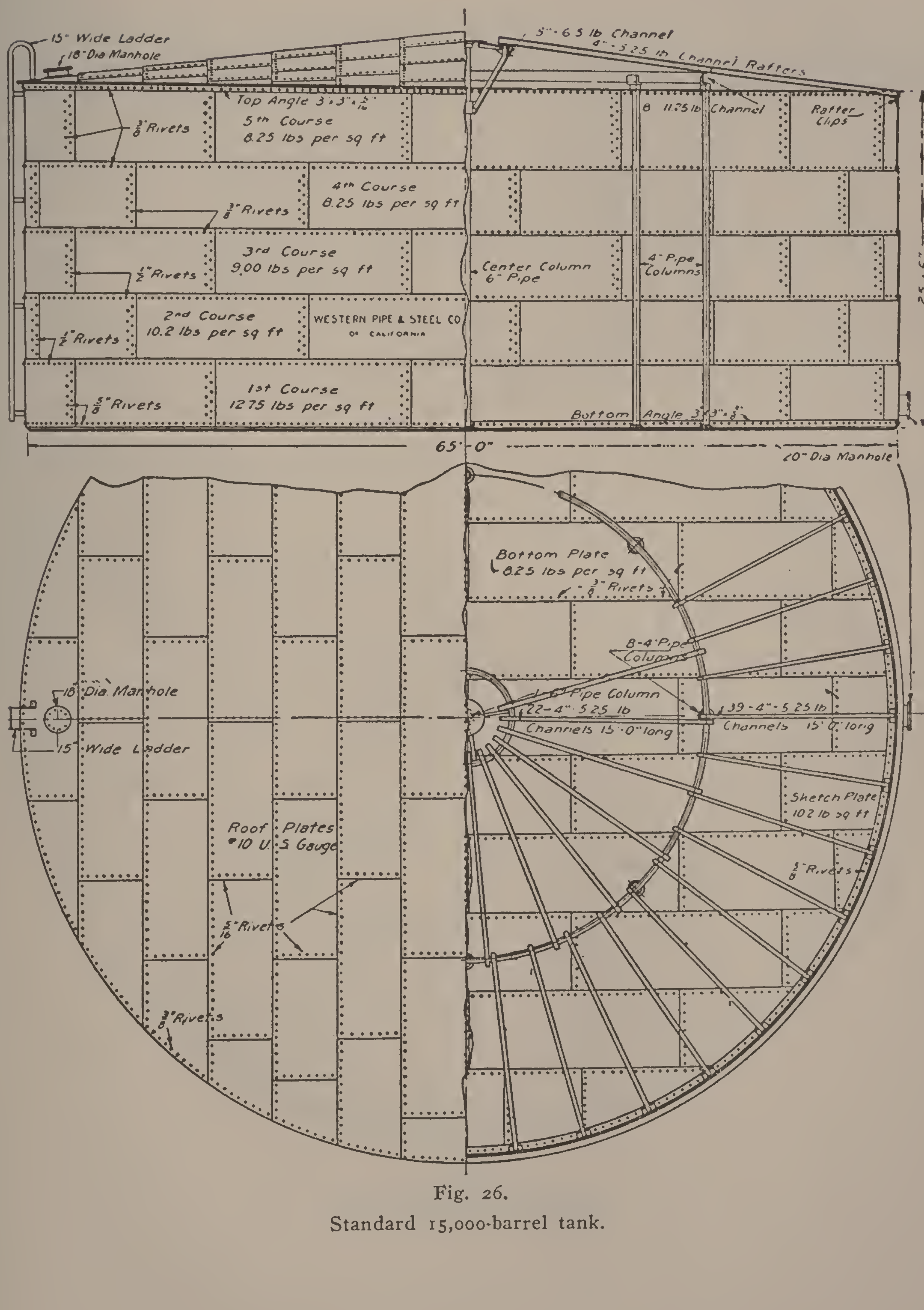


Fig. 26.

Standard 15,000-barrel tank.

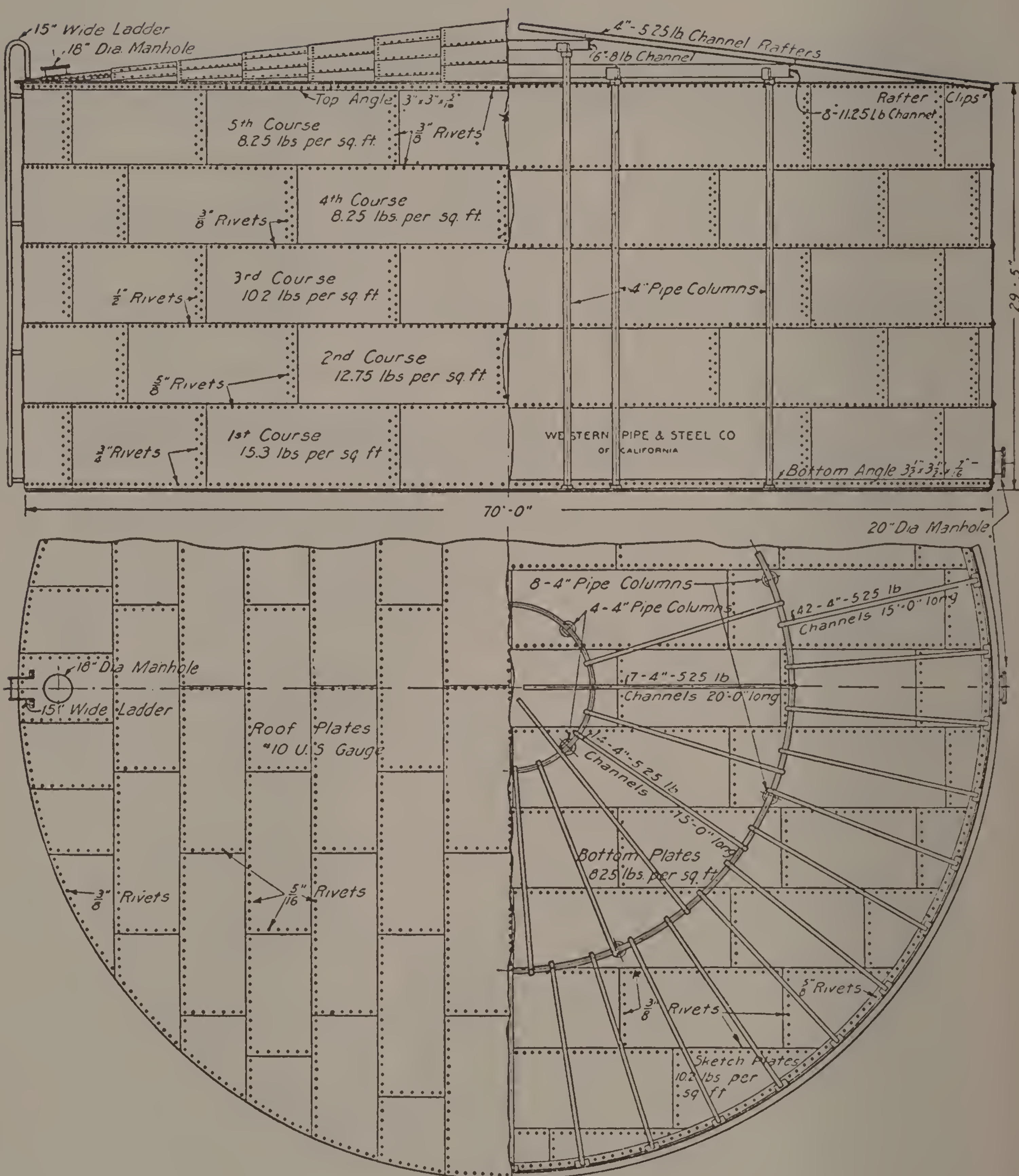


Fig. 27.
Standard 20,000-barrel tank.

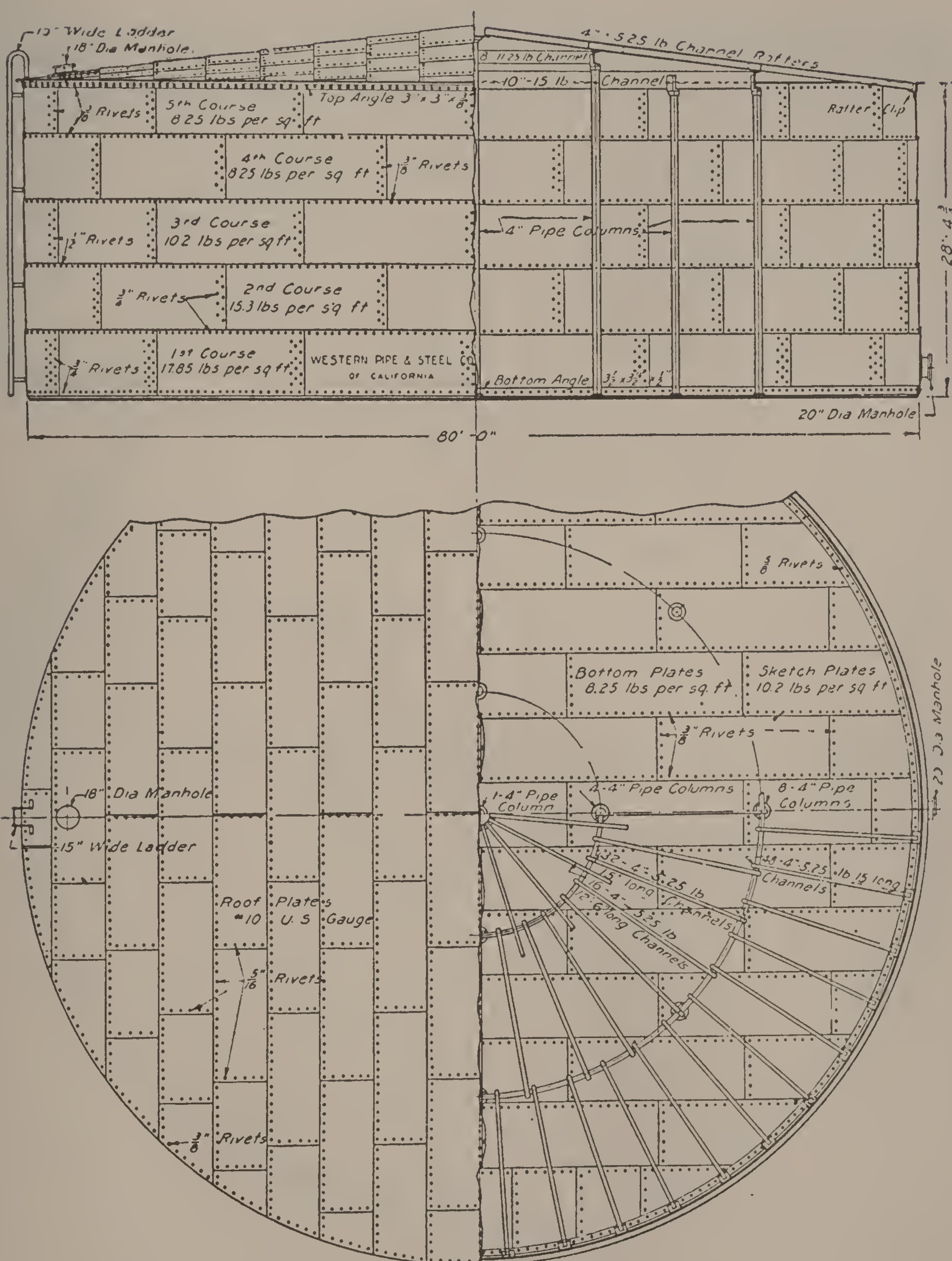


Fig. 28.
Standard 25,000-barrel tank.

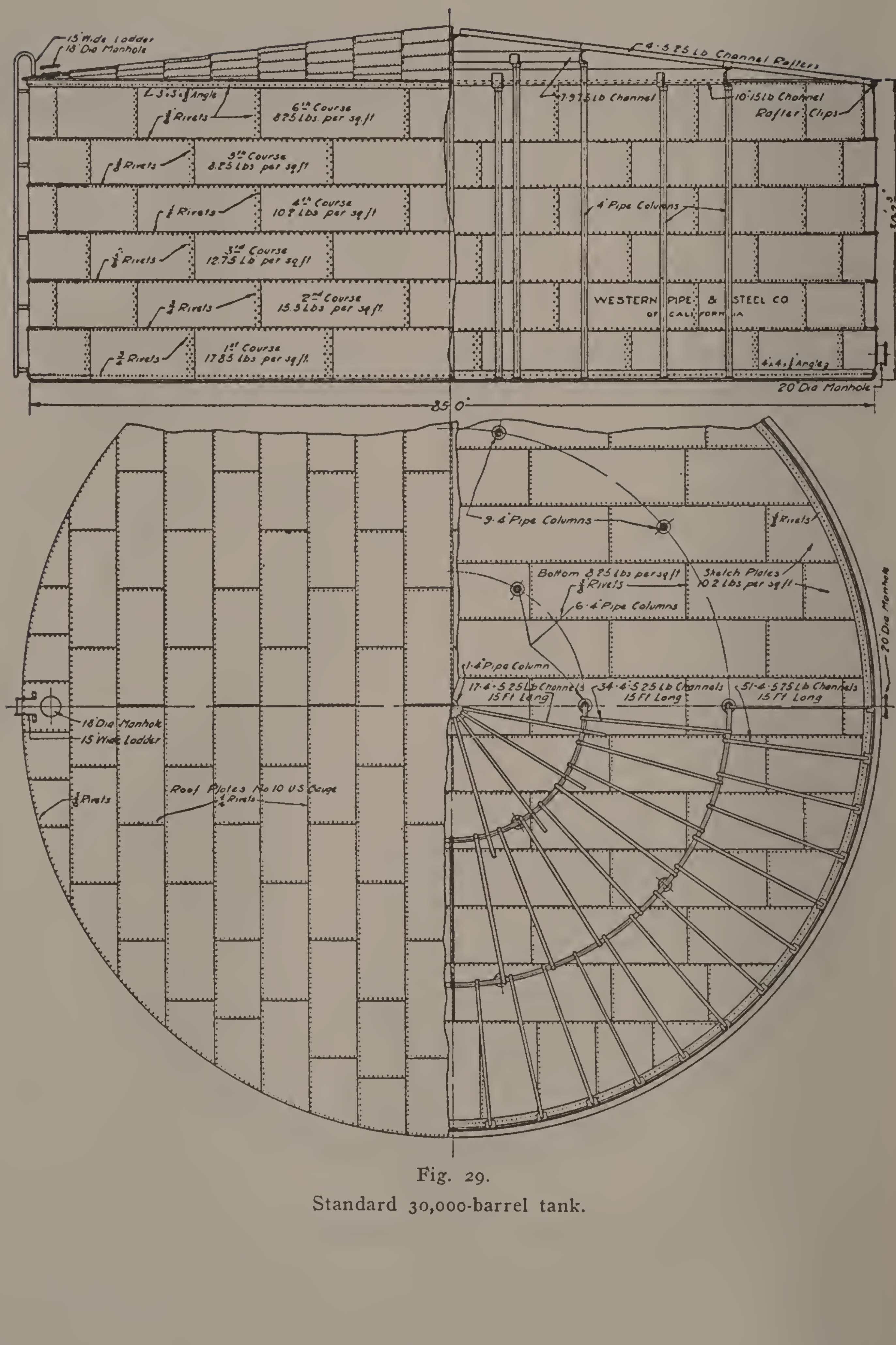


Fig. 29.
Standard 30,000-barrel tank.

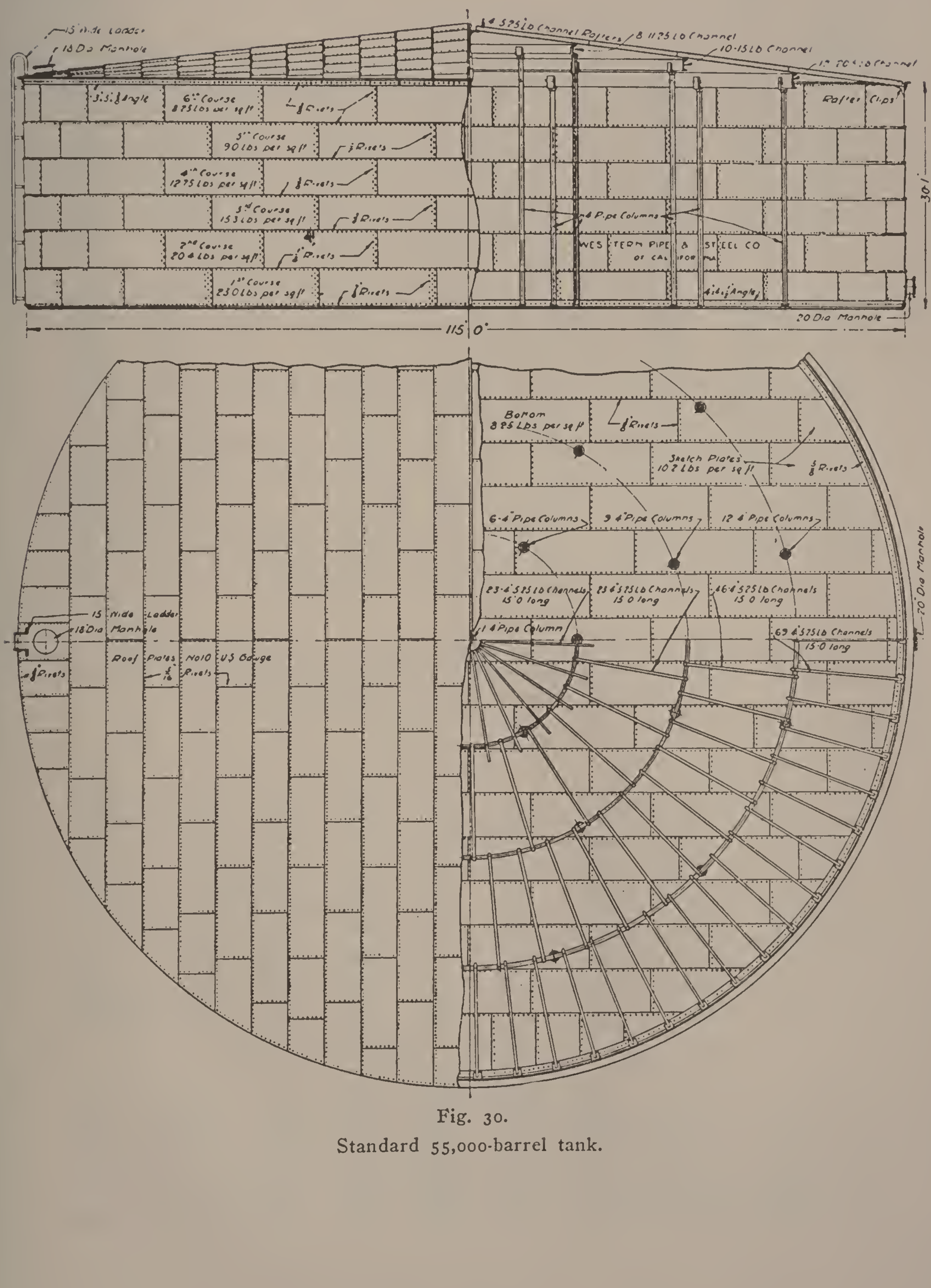


Fig. 30.
Standard 55,000-barrel tank.

(236) Standard Specifications for Bolted Tanks.—

Nominal capacity 42-gal. barrels	Diameter	Height	Bottoms	Shells 1st Ring	2nd Ring	3rd Ring	Decks Cone	Water seal
100	9′6½″	8′0½″	14 Ga.	14 Ga.			16 Ga.	14 Ga.
200	9′6½″	16′1″	14 Ga.	14 Ga.	14 Ga.		16 Ga.	14 Ga.
250	14′9″	8′0½″	12 Ga.	14 Ga.			16 Ga.	12 Ga.
500	14′9″	16′1″	12 Ga.	14 Ga.	14 Ga.		16 Ga.	12 Ga.
500	21′2⅝″	8′0½″	12 Ga.	14 Ga.			16 Ga.	12 Ga.
1,000	21′2⅝″	16′1″	12 Ga.	12 Ga.	14 Ga.		16 Ga.	12 Ga.
1,500	21′2⅝″	24′1½″	12 Ga.	12 Ga.	12 Ga.	14 Ga.	16 Ga.	12 Ga.
1,500	25′9¼″	16′1″	12 Ga.	12 Ga.	14 Ga.		16 Ga.	12 Ga.
2,000	29′8½″	16′1″	12 Ga.	12 Ga.	12 Ga.		14 Ga.	12 Ga.
2,250	25′9¼″	24′1½″	12 Ga.	12 Ga.	12 Ga.	14 Ga.	16 Ga.	12 Ga.
2,500	33′2½″	16′1″	12 Ga.	12 Ga.	12 Ga.		12 Ga.	12 Ga.
3,000	29′8½″	24′1½″	12 Ga.	10 Ga.	12 Ga.	12 Ga.	14 Ga.	12 Ga.
3,750	33′2½″	24′1½″	10 Ga.	10 Ga.	12 Ga.	12 Ga.	12 Ga.	12 Ga.
5,000	47′0″	16′1″	10 Ga.	8 Ga.	12 Ga.		12 Ga.	12 Ga.
5,000	38′7½″	24′1½″	10 Ga.	10 Ga.	10 Ga.	12 Ga.	12 Ga.	12 Ga.
10,000	54′11½″	24′1½″	3/16″	3/16″	8 Ga.	10 Ga.	12 Ga.	12 Ga.

(Courtesy Western Pipe and Steel Corporation)

CAPACITIES OF STEAM TRAP SARCO IN POUNDS OF WATER PER HOUR BASED ON THE SIZE OF THE DISCHARGE ORIFICES.

LOW PRESSURE

Lbs.	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″
1	500	600	900	1200	1700	1950	2300	2750	3200
5	550	660	990	1320	1820	2210	2600	2954	3410
10	605	726	1089	1452	2030	2440	2854	3242	3720
15	666	799	1198	1597	2270	2650	3182	3515	4150
20	733	879	1318	1757	2600	3100	3476	3702	4820
25	806	967	1450	1933	2950	3300	3640	4098	5300
30	887	1064	1595	2126	3400	3600	3960	4375	5870
50	920	1200	1650	2360	3885	4060	4320	4886	6400

HIGH PRESSURE (Smaller discharge openings)

Lbs.	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″
75	540	670	875	1250	1650	2050	2520	2800	3100
100	610	740	960	1375	1745	2200	2700	2950	3280
125	658	800	1020	1500	1860	2375	2875	3186	3420
150	735	875	1200	1610	1935	2490	3150	3300	4000
175	820	950	1350	1728	2100	2600	3280	3500	4300

Capacities of Steam Trap Sarco, in Square Feet of Radiation Surface on Basis of ⅓ Pound per Hour Condensation per Square Foot.

Lbs.	⅜″	½″	¾″	1″	1¼″	1½″	2″	2½″	3″
				Low Pressure					
1	750	900	1200	1400	1680	1800	2200	2600	3500
5	825	990	1320	1540	1740	2000	2425	2800	3750
10	907	1089	1452	1694	1980	2300	2600	3120	4200
15	998	1198	1597	1863	2200	2560	2950	3450	4540
20	1098	1318	1757	2049	2520	2870	3185	3900	4790
25	1208	1450	1933	2254	2850	3250	3470	4200	4980
30	1329	1595	2126	2479	3000	3500	3800	4750	5150
50	1570	1820	2630	2800	3500	4200	4500	5620	6200
			High Pressure (Smaller discharge openings)						
75	750	900	1325	1500	1800	1950	2150	2300	2650
100	825	968	1440	1720	1975	2100	2350	2540	2850
125	870	1020	1505	1870	2150	2300	2500	2750	3000
150	945	1200	1620	2000	2280	2470	2800	2900	3160
175	1060	1350	1785	2175	2450	2780	2940	3200	3450

(237) How to Compute the Required Amount of Fuel Oil for Boilers.—The required amount of heat needed to convert one pound of water at 212° F. into steam at the same temperature is 970.4 (as per the steam tables) B. t. u. and is known as the latent heat.

Hence:

W = Number of pounds of water per hour @ 212° F.
L = Latent heat.
y = Amount of heat (B. t. u.) equivalent to one boiler horsepower-hour.

Then:

$$y = W \times L.$$

B.t.u. = Calorific value per pound of fuel oil.
% = Boiler efficiency.
z = Pounds of fuel oil required per one boiler horsepower-hour.

Then:

$$z = \frac{y}{\text{B. t. u.} \times \%}.$$

To compute the required amount of fuel oil then,

H.P. = Total rated horsepower of all boilers.
N = Number of hours boilers are operated per day.

z = Pounds of fuel oil required per one boiler horse-power-hour.

Z = Number of pounds of fuel oil required per day.

Then:

$$Z = H.\ P. \times z \times N + (8\%).$$

NOTE: 8 per cent is added to the product in above formula to cover any contingency *i. e.*, caused when commencing to fire the boilers.

It is customary in computing the tankage for fuel oil to cover a period of at least thirty days, which is ample before a replenished supply is obtained. Also another important point to consider is to have additional tankage so as to avoid heavy demurrage rates.

(238) Rails.—

RAILS.

Weight per yard	Tons per mile
8 lbs.	$12\,{}^{1280}/_{2240}$
12 "	$18\,{}^{1920}/_{2240}$
16 "	$25\,{}^{320}/_{2240}$
25 "	$39\,{}^{640}/_{2240}$
30 "	$47\,{}^{320}/_{2240}$
35 "	55
40 "	$62\,{}^{1920}/_{2240}$
45 "	$70\,{}^{1600}/_{2240}$
50 "	$78\,{}^{1280}/_{2240}$
52 "	$81\,{}^{1600}/_{2240}$
56 "	88
57 "	$89\,{}^{1280}/_{2240}$
60 "	$94\,{}^{640}/_{2240}$
62 "	$97\,{}^{960}/_{2240}$
64 "	$100\,{}^{1280}/_{2240}$
65 "	$102\,{}^{320}/_{2240}$
68 "	$106\,{}^{1920}/_{2240}$
70 "	110
72 "	$113\,{}^{320}/_{2240}$
75 "	$117\,{}^{1920}/_{2240}$
76 "	$119\,{}^{960}/_{2240}$
78 "	$122\,{}^{1280}/_{2240}$
80 "	$125\,{}^{1600}/_{2240}$
85 "	$133\,{}^{1280}/_{2240}$
90 "	$141\,{}^{960}/_{2240}$
95 "	$149\,{}^{640}/_{2240}$
100 "	$157\,{}^{320}/_{2240}$
105 "	155
110 "	$172\,{}^{1920}/_{2240}$

To find the number of tons (of 2,240 lbs.) per mile of single track, multiply the pounds per yard by 11 and divide by 7.

(239) Fish Plates and Bolts.—

Length of rail, feet	No. joints per mile	No. fish plates per mile	No. bolts per mile
24	440	880	1760
25	422	844	1668
26	406	812	1624
27	391	782	1564
28	377	754	1508
30	352	704	1408
33	320	640	1280
45	235	470	940
60	176	352	704

(240) Average No. of Track Bolts in a Keg of 200 Lbs.—

⅞ x 3½ With hexagon nuts	170 Bolts
¾ x 3½ With square nuts	210 Bolts
¾ x 3¾ With hexagon nuts	220 Bolts
⅝ x 2½ With square nuts	370 Bolts
½ x 2½ With square nuts	650 Bolts
½ x 3 With square nuts	600 Bolts

(241) Cross Ties.—

Per Mile of Single Track.

From center to center, 18 inches	3,520 Ties
From center to center, 24 inches	2,641 Ties
From center to center, 27 inches	2,348 Ties
From center to center, 30 inches	2,113 Ties
From center to center, 33 inches	1,921 Ties
From center to center, 36 inches	1,761 Ties

(242) Table for the Elevation of the Outer Rail on Curves.—

The following table, calculated by A. Mordecai, C .E., is intended to serve for the principal gauge used in this country, *viz.*: 4 feet 8½ inches. The proper elevation is calculated for nine different speeds, from 15 to 60 miles an hour, and for curves from 30 minutes to 35 degrees radius.

Degree of curvature	Rate of speed in miles per hour								
	15	20	25	30	35	40	45	50	60
	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
30′	1/16	1/8	3/16	1/4	3/8	1/2	11/16	13/16	1 1/8
1°00′	1/8	1/4	7/16	5/8	11/16	1 1/16	1 5/16	1 5/8	2 3/8
1°30′	3/16	3/8	5/8	7/8	1 3/16	1 9/16	2	2 1/2	3 1/2
2°00′	5/16	1/2	13/16	1 1/8	1 5/8	2 1/8	2 11/16	3 1/4	4 5/8
2°30′	3/8	11/16	1	1 1/2	2	2 11/16	3 5/16	4 1/16	5 15/16
3°00′	7/16	13/16	1 1/4	1 3/4	2 7/16	3 1/8	4	4 15/16	7
3°30′	1/2	15/16	1 7/16	2 1/16	2 13/16	3 11/16	4 5/8	5 3/4	8 5/16
4°00′	9/16	1 1/16	1 5/8	2 3/8	3 1/4	4 3/16	5 5/16	6 1/4	9 7/16
4°30′	11/16	1 3/16	1 7/8	2 5/8	3 5/8	4 11/16	6	7 3/8	10 9/16
5°00′	3/4	1 5/16	2 1/16	3	4	5 1/4	6 5/8	8 3/16	11 7/8
6°00′	7/8	1 9/16	2 7/16	3 1/2	4 13/16	6 5/16	8	9 7/8	14 1/16
7°00′	1	1 7/8	2 7/8	4 1/8	5 5/8	7 3/8	9 1/4	11 1/2	16 1/2
8°00′	1 3/16	2 1/8	3 5/16	4 11/16	6 7/16	8 3/8	10 5/8	13 1/8	18 7/8
9°00′	1 5/16	2 3/8	3 11/16	5 5/16	7 1/4	9 7/16	11 15/16	14 3/4	21 5/16
10°00′	1 1/2	2 5/8	4 1/8	5 7/8	8	10 1/2	13 1/4	16 3/8	23 1/2
12°00′	1 3/4	3 1/8	4 15/16	7 1/16	—	—	—	—	—
15°00′	2 1/4	3 15/16	6 1/8	9 1/16	—	—	—	—	—
18°00′	2 11/16	4 11/16	7 3/8	10 9/16	—	—	—	—	—
20°00′	2 15/16	5 1/4	8 3/16	11 3/4	—	—	—	—	—
25°00′	3 13/16	6 13/16	10 5/8	15 5/16	—	—	—	—	—
30°00′	4 3/8	7 13/16	12 3/16	17 1/2	—	—	—	—	—
35°00′	5 1/16	9 1/16	14 1/4	20 5/16	—	—	—	—	—

To Find the Angle of a Frog Required for any Turnout.

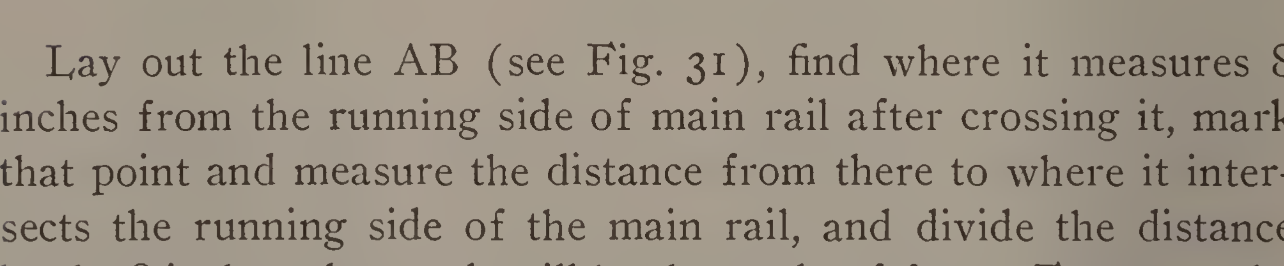


Fig. 31.

Lay out the line AB (see Fig. 31), find where it measures 8 inches from the running side of main rail after crossing it, mark that point and measure the distance from there to where it intersects the running side of the main rail, and divide the distance by the 8 inches, the result will be the angle of frog. For example, suppose the line AB to be 8 inches from main rail at a point 60 inches from the point of intersection, then 60 divided by 8 = 7½. Frog required is No. 7½ or 1 to 7½.

(243) TO FIND THE ANGLE OF A FROG.—

Divide the distance A B by the sum of the distances C D and E F. For example, suppose A B to equal 72 inches, C D 8 inches, and E F 4 inches, then 72 divided by 12 equals 6. Angle or spread of frog is 1 in 6. (See Fig. 32.)

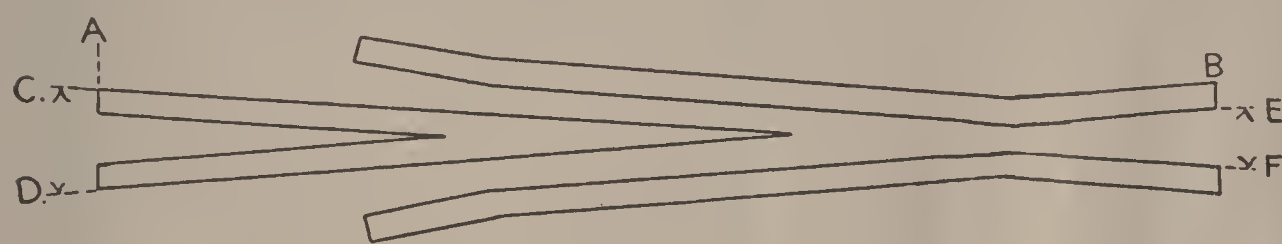


Fig. 32.

TABLE FOR PUTTING IN FROGS AND SWITCHES.

Proportion of frog	Length of frog	Angle of frog	Radius of curve	Distance from head block to point of frog	Crotch frog: Proportion of frog	Crotch frog: Length of frog	Crotch frog: Distance from head block to point of frog	
1 to 4	5 ft.	14°15′	165 ft.	28 ft.	1 to 3	4 ft.	17 ft.	Gauge 5 feet 5-inch throw
1 to 5	5 ft.	11°25′	254 ft.	35 ft.	1 to $3^2/_3$	4 ft.	21 ft.	
1 to 6	6 ft.	9°32′	365 ft.	42 ft.	1 to $4^1/_3$	5 ft.	25 ft.	
1 to 7	7 ft.	8°10′	566 ft.	48 ft.	1 to 5	5 ft.	28 ft.	
1 to 8	8 ft.	7°09′	642 ft.	57 ft.	1 to $5^2/_3$	5 ft. 8 in.	34 ft.	
1 to 9	9 ft.	6°21′	811 ft.	64 ft	1 to $6^1/_3$	6 ft. 4 in.	38 ft.	
1 to 10	10 ft.	5°44′	1005 ft.	71 ft.	1 to 7	7 ft.	41 ft.	
1 to 11	11 ft.	5°12′	1210 ft.	78 ft.	1 to $7^2/_3$	7 ft. 8 in.	45 ft.	
1 to 12	12 ft.	4°46′	1400 ft.	86 ft.	1 to $8^1/_3$	8 ft. 4 in.	50 ft.	
1 to 4	5 ft.	14°15′	155 ft.	26 ft.	1 to 3	4 ft.	16 ft.	Gauge 4′ 8½ inch 5-inch throw
1 to 5	5 ft.	11°25′	239 ft.	32 ft.	1 to $3^2/_3$	4 ft.	20 ft.	
1 to 6	6 ft.	9°32′	345 ft.	39 ft.	1 to $4^1/_3$	5 ft.	23 ft.	
1 to 7	7 ft.	8°10′	431 ft.	46 ft.	1 to 5	5 ft.	28 ft.	
1 to 8	8 ft.	7°09′	606 ft.	52 ft.	1 to $5^2/_3$	5 ft. 8 in.	31 ft.	
1 to 9	9 ft	6°21′	764 ft.	59 ft.	1 to $6^1/_3$	6 ft. 4 in.	35 ft.	
1 to 10	10 ft.	5°44′	979 ft.	65 ft.	1 to 7	7 ft.	37 ft.	
1 to 11	11 ft.	5°12′	1096 ft.	73 ft.	1 to $7^2/_3$	7 ft. 8 in.	42 ft.	
1 to 12	12 ft.	4°46′	1246 ft.	80 ft.	1 to $8^1/_3$	8 ft. 4 in.	46 ft.	
1 to 4	4 ft.	14°15′	102 ft.	14 ft.	1 to 3	4 ft.	8 ft.	Gauge 3 feet 5-inch throw
1 to 5	5 ft.	11°25′	154 ft.	19 ft.	1 to $3^2/_3$	4 ft.	11 ft.	
1 to 6	6 ft.	9°32′	220 ft.	23 ft.	1 to $4^1/_3$	4 ft.	13 ft.	
1 to 7	7 ft.	8°10′	296 ft.	27 ft.	1 to 5	5 ft.	15 ft.	
1 to 8	8 ft.	7°09′	388 ft.	32 ft.	1 to $5^2/_3$	5 ft.	18 ft.	
1 to 9	9 ft.	6°21′	486 ft.	36 ft.	1 to $6^1/_3$	6 ft.	20 ft.	
1 to 10	10 ft.	5°44′	606 ft	41 ft.	1 to 7	7 ft.	22 ft.	
1 to 11	11 ft.	5°12′	732 ft.	45 ft.	1 to $7^2/_3$	7 ft.	25 ft.	
1 to 12	12 ft.	4°46′	66 ft.	50 ft.	1 to $8^1/_3$	8 ft.	27 ft.	

For split switch, place heel of switch same distance from point of frog as head block:

8 feet switch points are suitable for frogs 1 to 4, 1 to 5, or 1 to 6
10 feet switch points are suitable for frogs 1 to 7, 1 to 8, or 1 to 9
15 feet switch points are suitable for frogs 1 to 10, 1 to 11, or 1 to 12

(244) Cast Iron Washers.—

Bolt, inches	Hole, inches	Diameter, inches	Thickness, inches	Approximate weight
1/2	5/8	2 5/8	11/16	9 oz.
5/8	3/4	2 3/4	3/4	12 oz.
3/4	7/8	3 1/8	7/8	1 lb.
7/8	1	3 1/2	15/16	1 lb. 6 oz.
1	1 1/8	4 1/8	1	2 lbs.
1 1/8	1 1/4	4 1/2	1 1/8	2 lbs. 8 oz.
1 1/4	1 3/8	5 1/2	1 3/16	4 lbs. 4 oz.
1 3/8	1 1/2	5 1/2	1 1/4	4 lbs. 6 oz.
1 1/2	1 5/8	6	1 1/4	5 lbs. 8 oz.

(245) Standard Wrot Iron Washers.—

Diameter	Size of hole	Thickness wire gauge	Size of bolt
9/16	1/4	18	3/16
3/4	5/16	16	1/4
7/8	3/8	16	5/16
1	7/16	14	3/8
1 1/4	1/2	14	7/16
1 3/8	9/16	12	1/2
1 1/2	5/8	12	9/16
1 3/4	11/16	10	5/8
2	13/16	10	3/4
2 1/4	15/16	9	7/8
2 1/2	1 1/16	9	1
2 3/4	1 1/4	9	1 1/8
3	1 3/8	9	1 1/4
3 1/4	1 1/2	8	1 3/8
3 1/2	1 5/8	8	1 1/2
3 3/4	1 3/4	8	1 5/8
4	1 7/8	8	1 3/4
4 1/4	2	8	1 7/8
4 1/2	2 1/8	8	2
4 3/4	2 3/8	5	2 1/4
5	2 5/8	4	2 1/2

(246) Swedged Nipples.—

SWEDGED NIPPLES.

Regular Casing Sizes—Made from Standard Weight Casing.

Size, inches	Length, inches	Weight, lbs.	Price, each
4¼ x 2	10	7	$5.50
4¼ x 2½	10	7	5.25
4¼ x 3	10	7	5.00
4¼ x 3½	10	7	5.00
4½ x 2	10	7	5.00
4½ x 3	10	7	5.00
4½ x 4	10	7	4.50
5 x 2	11	11	5.50
5 x 2½	10	10	5.25
5 x 3	10	10	5.00
5 x 3½	10	10	5.00
5 x 4	10	10	4.50
5 x 4¼	10	10	4.50
5 3/16 x 2	11	11	6.50
5 3/16 x 2½	10	10	6.00
5 3/16 x 3	10	10	5.50
5 3/16 x 3½	10	10	5.50
5 3/16 x 4	10	10	5.00
5 3/16 x 4½	10	10	4.75
5 3/16 x 5	10	10	4.00
5⅝ x 2	12	13.5	7.00
5⅝ x 2½	12	13.5	6.75
5⅝ x 3	10	12	6.50
5⅝ x 3½	10	12	6.50
5⅝ x 4	10	12	6.25
5⅝ x 4¼	10	12	6.25
5⅝ x 5	10	12	6.00
5⅝ x 5 3/16	10	12	6.00
6¼ x 2	12	13	7.25
6¼ x 2½	12	13	7.00
6¼ x 3	12	13	6.75
6¼ x 3½	12	13	$6.50
6¼ x 4	11	12	6.50
6¼ x 4¼	11	12	6.50
6¼ x 4½	11	12	6.25
6¼ x 5	10	10.5	6.00
6¼ x 5 3/16	10	10.5	6.00
6¼ x 5⅝	10	10.5	6.00
6⅝ x 2	14	19	8.50
6⅝ x 2½	14	19	8.25
6⅝ x 3	14	19	8.00
6⅝ x 3½	14	19	7.75
6⅝ x 4	12	16.5	7.50
6⅝ x 4½	12	16.5	7.50
6⅝ x 5	12	16.5	7.50
6⅝ x 5 3/16	12	16.5	7.50
6⅝ x 5⅝	12	16.5	7.25
6⅝ x 6	12	16.5	7.00
6⅝ x 6¼	12	16.5	7.00
8¼ x 2	14	28	15.00
8¼ x 2½	14	28	13.50
8¼ x 3	14	28	12.00
8¼ x 3½	14	28	11.75
8¼ x 4	14	28	11.50
8¼ x 4½	14	28	11.50
8¼ x 5	12	25	11.00
8¼ x 5 3/16	12	25	10.00
8¼ x 5⅝	12	25	9.00
8¼ x 6	12	25	9.00
8¼ x 6¼	12	25	9.00
8¼ x 6⅝	12	25	9.00

Contributed by Oil Well Supply Co.

SWEDGED NIPPLES.

Fig. 33.

Extra Heavy.

Size, inches	Length overall, inches	Length of neck, inches	Weight, lbs.	Price pipe machine threaded, each	*Price lathe threaded, each
4 x 2	16	6	16	$12.00	$30.00
4 x 2½	16	6	17	10.50	25.50
4 x 3	16	6	18	9.00	24.00
4½ x 2½	18	6	24	30.00	51.00
4½ x 3	18	6	25	27.00	45.00
4½ x 4	18	6	26	25.25	39.00
6 x 2½	18	6	37	31.50	42.00
6 x 4	18	6	39	24.00	39.00
6 x 4½	18	6	40	19.50	36.00
8 x 4	18	6	57	33.00	60.00
8 x 6	18	6	60	30.00	48.00
Double Extra Heavy.					
4 x 2	16	6	32	$51.00	$60.00
4 x 2½	16	6	33	45.00	54.00
4 x 3	16	6	34	30.00	48.00
4½ x 2½	18	6	42	48.00	57.00
4½ x 3	18	6	44	42.00	51.00
4½ x 4	18	6	46	36.00	45.00
6 x 2½	18	6	70	54.00	63.00
6 x 4	18	6	72	48.00	57.00
6 x 4½	18	6	76	42.00	51.00
8 x 4	18	6	100	72.00	100.00
8 x 6	18	6	105	60.00	90.00

* Lathe threaded insures ends in line. Always specify whether pipe machine threaded or lathe threaded is desired.

Contributed by Oil Well Supply Co.

(247) Data on Common Nails.—

Size	Length, inches	Gauge number	Approximate number to pound
2d	1	15	876
3d	1¼	14	568
4d	1½	12½	316
5d	1¾	12½	271
6d	2	11½	181
7d	2¼	11½	161
8d	2½	10¼	106
9d	2¾	10¼	96
10d	3	9	69
12d	3¼	9	63
16d	3½	8	49
20d	4	6	31
30d	4½	5	24
40d	5	4	18
50d	5½	3	14
60d	6	2	11

(248) Specifications for Celotex Insulation of Oil Tanks.—Celotex Insulation Board should be furnished for the insulation of oil tanks, size of Celotex sheets 4 ft. by 10 ft. or 12 ft. and ½″ thick.

Not less than two layers of Celotex and preferably three, should be applied to the oil tanks.

The first layer of Celotex should be directly applied to the tanks and held in place by two by four wood braces until the entire layer is applied, at which time No. 9 steel wire bands or telegraph wire should be applied around the tank to hold the Celotex layer in place. The Celotex layer on top of the tank should be held in place by the wires or bands running across the top and their ends secured to the horizontal wires running around the tanks.

After the first layer of Celotex is applied in the manner above indicated the second and third layers should be applied in a similar manner.

After the Celotex Insulation Board is applied it should be covered with two coats of heavy asphaltum paint or it may be protected by so-called rubber roofing applied by wiring on in a manner similar to that described for the Celotex and the joints of the roofing sealed with pitch or asphalt.

NOTE:—The use of two layers of Celotex Insulation will have a conductivity less than 0.33 per hour per degree difference in temperature per square foot of surface. When the insulation is covered with a roofing material, which is recommended in the specifications, the heat conductivity per square foot will only be 0.25 per hour per degree difference in temperature.

(249) Horsepower Chart for Gears and Pulleys.—

(Contributed by the Mesta Machine Co.)

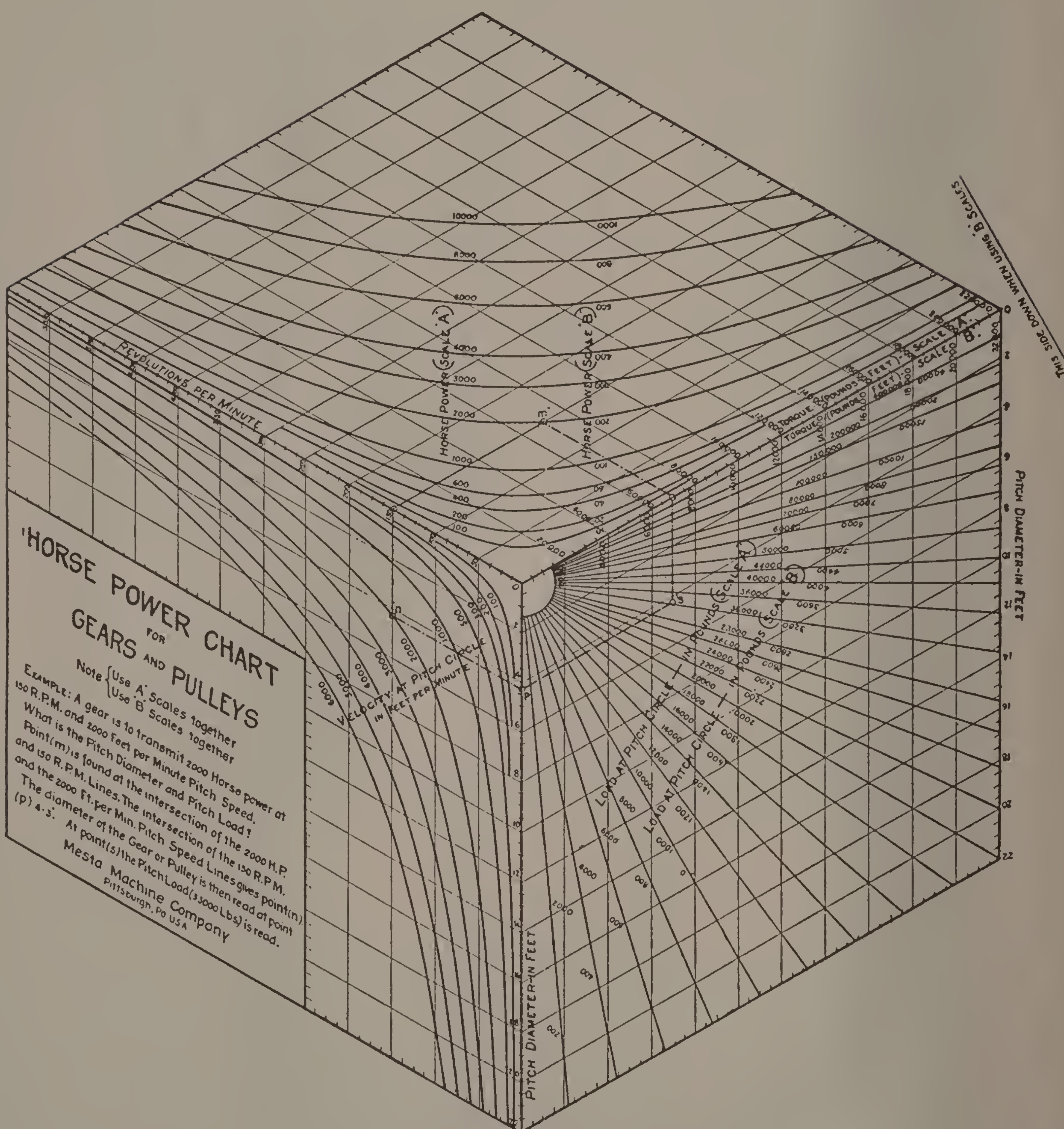


Fig. 34.

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